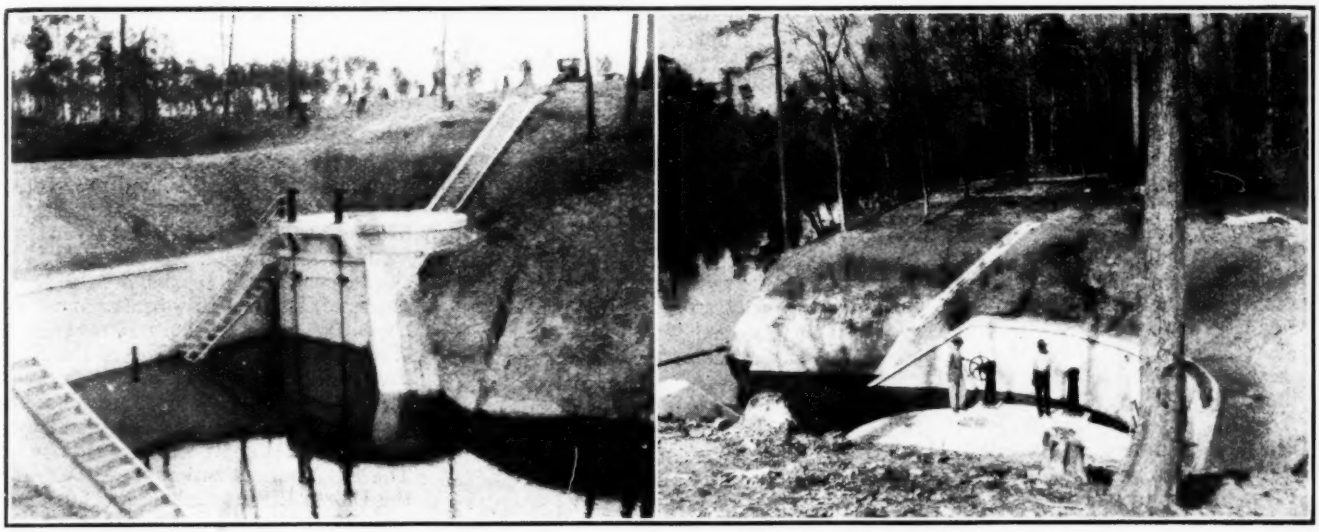
Water Works and Sewerage

Vol. LXXVI OCTOBER, 1929 No. 10



Left—Intake Shaft and Forebay at Edisto River. Right—Intake Shaft and Forebay, Looking Upstream

The New Water Supply of Charleston, S. C.

Edisto-Ashley River Tunnel Driven 4½ Miles Through Marl

By J. E. GIBSON

Manager and Engineer, Water Department, Charleston, S. C.

As a result of the unprecedented droughts occurring in the southeastern states during the fall of 1926, the Commissioners of Public Works of the city of Charleston, S. C., operating the water department, authorized the department to make a study of the water supply resources of Charleston with the idea of developing an additional supply. These studies were carried out during the summer of 1927, and resulted in the department recommending the Edisto River at Givhans Ferry as the supply.

Goose Creek, the present supply source, has a drainage area of 42½ square miles. Lying immediately to the west of this drainage area is the Ashley River, having a drainage area of 245 square miles, upon which, at Bacon's bridge, there have been built a dam and an auxiliary pumping station. The Edisto River lies to the west of the Ashley River and has a drainage area at Givhans Ferry of 2,476 square miles, with the divide between the Ashley and the Edisto within ¼ mile of the Edisto River.

River Water Diverted Through Tunnel.—On account of the nature of the drainage area above Bacon's bridge—low, swampy, heavily timbered area, with marl formation lying within two to three feet of the surface—the flow of the Ashley River at Bacon's bridge reaches as low a quantity as 50,000 gallons per day, whereas the Edisto River to the west of the Ashley has an average flow in excess of 300 m.g.d. with a minimum flow probably never less than 150 m.g.d. It was proposed, therefore, to divert sufficient waters of the Edisto River into the Ashley River to produce at all times an adequate supply of water for the pumping station located at Bacon's bridge on the Ashley River. This pumping station delivers the water under a 26-ft. static head into the drainage area of Goose Creek, whence the water flows by gravity to the Goose Creek pumping station and filter plant for ultimate use. A series of levels run between the Edisto River and Goose Creek developed the fact that the fall between the normal elevation of the water in the Edisto River at Givhans Ferry and a small tributary of the Ashley River that could be reached within 4½ miles of Givhans, was 13 ft.; that is to say, the elevation of the Ashley River at the nearest point was 14 ft. and the Edisto River had a normal stage of water of 27 ft. The divide between the Edisto and the Ashley River is a high table-land with an average elevation of 60 ft. for from 1½ to 2 miles. Therefore, to divert the waters from the Edisto to the Ashley, it was necessary either to tunnel this distance or to put in a pumping station and pump the water through pipes across the table-land. The latter consideration proving prohibitory as to cost for the quantity of water required, it was determined to tunnel. This constitutes the unusual feature of the job—a 4½-mile tunnel in the low, flat coastal plain of South Carolina. The tunnel is really not a tunnel in the sense that we ordinarily think of a tunnel, but is rather a conduit as it is well below the hydraulic grade line between the two sources and acts as an inverted syphon.

Tunnel Driven in Marl.—The beds of both the Ashley and the Edisto rivers are eroded down to the marl; in fact, the east bank of the Edisto is a sheer bluff of about 30 ft. of marl formation. This marl is a semi-limestone formation that can be readily cut by sharp tools such as mattocks or picks. It is homogeneous in nature and shows very little erosion by the current. It was this condition that led Mr. McDowell, assistant manager and engineer, and the writer to decide on tunneling, as all our in-

vestigations developed the fact that the marl would withstand erosion even where the velocities were very high. Test borings were made every half-mile along the line of the projected tunnel and the elevation of the marl determined, and with this information available it was an easy job to locate the tunnel at the proper elevation to maintain a satisfactory covering of marl at all points.

Pumping Scheme.—The design contemplates ultimately carrying the tunnel to the Goose Creek pumping station, a total distance of 22½ miles. The work undertaken, however, embraced only the tunnel from the Edisto River to the tributary of the Ashley River, a distance of 4½ miles, passing under the divide between the two rivers and thence continuing with 1½ miles of open canal. The canal is really an improvement in alignment of the small tributary into which the outlet shaft of the tunnel is discharged. Water will flow from the Edisto River through the tunnel for a distance of 4½ miles, thence through improved canal to the Ashley River proper and thence down the channel of the Ashley River 8 miles to the Bacon's bridge pumping station. Here it will be pumped by Diesel-engine-driven centrifugal pumps through a 24-inch pipe line to the Goose Creek drainage basin. The present capacity is 5 m.g.d. with provision made for increasing to 10 m.g.d. when required. When this latter figure is reached, it is hoped that funds will be available to continue the tunnel work the remaining 18 miles to the Goose Creek pumping station. The ultimate capacity of the tunnel when completed to Goose Creek will be 25 m.g.d. and the fall in the tunnel from the inlet to the outlet at Goose Creek will be 18 ft. The tunnel section is horseshoe shaped, the upper half being a circle of 3½-ft. radius and the lower quarters and bottom being segments of 7-ft. radius struck from the ends of the horizontal diameter and the top of the upper circle.

Cost to Date.—Plans were completed, and bids were opened on December 5, 1927. The contract was awarded to the MacDougald Construction Co., of Atlanta, Ga., on January 6, 1928. Charles C. Case was representative owner in charge and Barry Tufts was general superintendent. The total cost of the work, exclusive of the open canal, which has not as yet been completed on account of the continued wet weather and the resulting inaccessibility, was $383,575.26, made up as follows:

Engineering, preliminary surveys, inspection during construction and overhead	$ 23,432.58
Legal expense, land and rights-of-way	10,203.12
Contract, MacDougald Construction Co.	349,939.56
Total	$383,575.26

Composition of Marl.—There were no particularly difficult engineering feats required in the construction of the tunnel. The underlying geologic formation of the coastal plain from Georgetown at the mouth of the Santee River to as far south as Savannah is marl, which occurs in the Cretaceous, Eocene, Oligocene, Miocene, Pliocene, and Pleistocene periods. The elevation of the marl formation on the Cooper River and Goose Creek is about —3, mean sea level, with a gentle rising slope toward the west until it reaches the Edisto River, where it outcrops in a sheer bluff on the east bank of the Edisto River 15 or 20 ft. above mean water level, or elevation 42 ft. above mean sea level. The marl through which the tunnel is constructed probably belongs to the Miocene period.

The analysis of the marl runs about as follows:

Sulphur trioxide	Trace
Silicon dioxide	13.04%
Iron and aluminum oxide	1.78%
Magnesium oxide	Trace
Calcium oxide	*46.16%

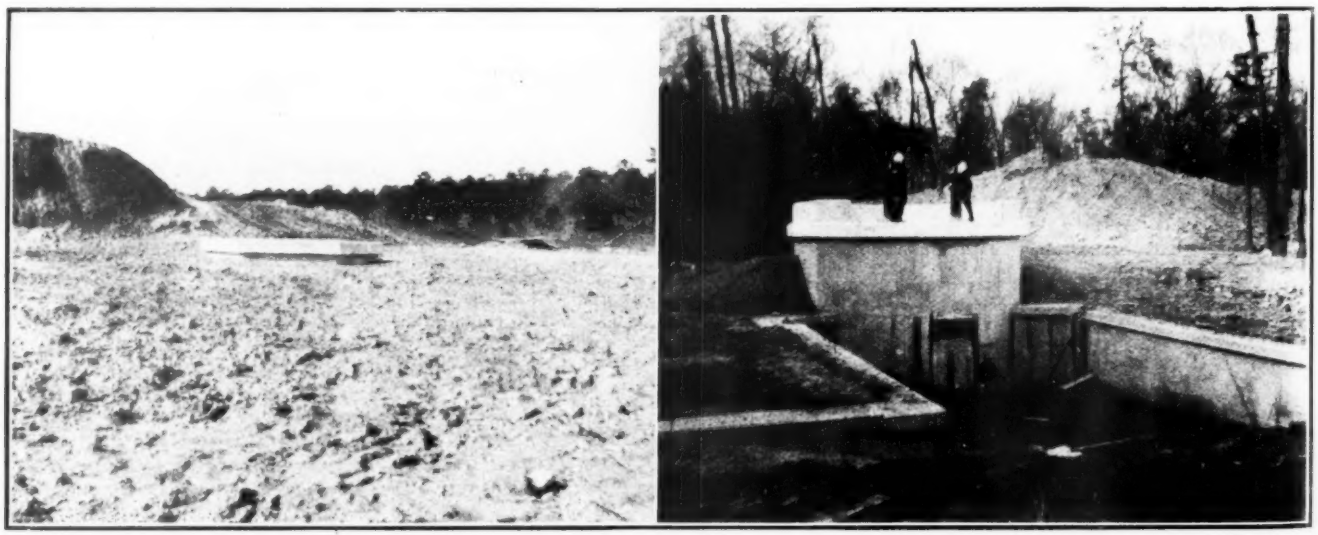
*Equivalent to calcium carbonate 81.76%.

Shafts and Headworks.—The contract as awarded consisted of the inlet portal shaft, the exit shaft, three intermediate shafts located about one mile apart and 4½ miles of tunnel, from a 40-ft. minimum to a 65-ft. maximum depth below the surface of the ground. The order of construction was to sink all shafts to the desired grade and then drive headings in both directions from the intermediate shafts and in one direction from the inlet and outlet shafts. The tunnel was given a slight ascending grade from each shaft heading so that any water that might be encountered during construction would drain to the shafts. Very little water was encountered. All shafts are concrete lined from bottom to surface and provided to receive stop logs so that any section of the tunnel can be isolated and unwatered if required.

The headworks consist of a concrete entrance having an opening into the river 20 ft. wide, with a minimum depth of 3 ft. at low-water stage of the river. The water will flow into this inlet, thence through racks and screens controlled by two 48-in. square sluice gates, down the inlet shaft and into the tunnel. The minimum elevation of the water in the Edisto River is taken as 23 ft.; normal, 27 ft.

Methods of Construction.—The contractor erected at each shaft a stiff-leg derrick with gasoline or air-driven hoists for lifting the muck from the shaft and tunnel, and at inlet shafts No. 1 and No. 3 erected a 1,050-ft. Diesel-engine-driven Sullivan compound compressor. These units were connected on the surface with 3½-in. wrought-iron pipe, and at each end extended to include the inlet and outlet shafts. At all shafts necessary air valves and take-off lines were connected to this air line. A small gasoline-driven electric light plant was installed for furnishing light in the tunnel and shafts. Under ground, the air lines were 2½ and 3 in. in diameter.

At first it was thought unsafe to do any blasting in the tunnel but careful experimentation after the work started disclosed that a moderate amount of



Left—Intermediate Shaft No. 3 and Spoil Bank. Right—Outlet Shaft and Spillway Just Before Completion

powder or gelatin could be used to advantage. Light charges of ½ lb. of 40 per cent gelatin in each of five holes at a depth of from 4½ to 5 ft., spaced about 2 ft. from the circumference of the tunnel, were found to remove a satisfactory amount of material without injury. After this material was removed, the tunnel section was finished to size with pneumatic spades and hand adzes. Alignment was maintained as in other tunnel construction. The muck was removed in small removable body cars over a light-rail 20-in.-gauge track to the shafts, where the body of the car was raised to the surface. Here the muck was dumped into a larger car and carried to spoil banks. Man power was used for muck cars.

Progress of Work.—Progress in driving the tunnel was made as follows:

The heading between the inlet shaft and the west heading of No. 1 shaft was holed through September 15, 1928.

The east heading from No. 1 shaft to the west heading of No. 2 shaft was holed through October 2, 1928.

The east heading between No. 2 shaft and the west heading of No. 3 shaft was holed through on the afternoon of November 1, 1928.

The east heading from shaft No. 3 to the west heading of the outlet shaft was holed through November 9, 1928.

The maximum error in alignment at meeting points was 17 in. and the minimum ½ in. We consider this exceptionally good engineering work, for the longest base line available at the commencement of the work was the diameter of the shafts, a maximum length of 11 ft., and a minimum length of 8 ft. The lapse of time between the holing through of the last shaft and the final completion of the work was taken up in the final finishing of the surface of the tunnel, completion of the concrete shafts, capping, removal of plant equipment, etc.

The marl throughout the 4½ miles of tunnel was quite uniform in character, showing no tendency to squeeze or fall. The tunnel is unlined throughout its length and has been filled with water since April 1, 1929, but has not been put into service as the rainfall has been more than sufficient to maintain the Goose Creek impounding reservoir full to overflowing.

Engineering Personnel. — All engineering work was carried out by the department, with F. B. McDowell, Jr., as engineer in immediate charge and Gabriel Cannon as resident engineer.

North Carolina Water Works Men Meet in November.—The 9th annual convention of the North Carolina Section, American Water Works Association, and 6th annual meeting of the North Carolina Sewage Works Association will be held jointly at the Sheraton Hotel, High Point, N. C., on Nov. 4, 5, and 6, 1929.

Artesian Water Supply of Memphis, Tenn.

The Geological Survey, United States Department of the Interior, has undertaken an investigation of the groundwater conditions in Tennessee in cooperation with the State Geological Survey. As a part of this larger program, about two months was spent in Memphis and vicinity during the summer of 1928 by F. G. Wells, of the United States Geological Survey. Automatic water-stage recorders were placed over representative wells and obtained continuous records of the depth to the water level in these wells. These records show with much precision the relation between the withdrawal of artesian water and the underground inflow of water to recharge the artesian reservoir. The longer the period covered by such records the more accurate are the conclusions that may be drawn. For this reason it is planned to continue observations at Memphis for several years.

Manuscript copies of a preliminary report giving the data that have thus far been obtained and such generalizations as can safely be made at this stage of the investigation, together with a map of Memphis showing the location of wells, tables of well data and chemical analyses, and illustrations, are now open for public inspection at the office of the Tennessee Geological Survey at Nashville, and at the Memphis Chamber of Commerce. This report gives a brief history of the artesian-water development of the area from 1867 up to the present time. The geology of the region is described, with particular reference to those formations that are important as producers of water. The Holly Springs and Grenada formations are the two most productive water-bearing formations in the area. The Holly Springs formation is encountered at about 450 ft. below the surface and continues to a depth of about 1,000 ft. The Grenada formation has a maximum thickness of 400 ft. and lies about 75 ft. below the surface. The Ripley formation, which also yields considerable water, is encountered at a depth of about 1,300 ft.

The total average daily pumpage from both public and private wells was 37,385,000 gal. in 1920 and remained below this figure until 1928, when it amounted to 38,600,000 gal. It is estimated that in 1928 about 2,000,000 gal. of water a day was pumped from the Ripley formation, the remainder coming from the group that includes the Grenada and Holly Springs formations.

The development of water supplies in Memphis during the last 10 years has caused an increase of over 1,000,000 gal. in daily pumpage, but as there has been a large increase in the area drawn upon by wells, the lowering of the water level has been less than if the wells had been concentrated in a smaller area. In view of the large quantity of water pumped, the loss in head is not great, and it is believed that additional supplies can be obtained, but future developments should be distributed as widely as possible. If more water is pumped the head will doubtless decline further, but for any increase that is expected in the immediate future the decline would hardly be great enough to be serious.

Analyses of water from wells in the Grenada formation show that in general it is fairly soft and has a moderately low content of dissolved mineral matter. Except for the slight trouble and expense involved in the removal of iron, water from the Grenada and Ripley formations is likely to be thoroughly satisfactory for all ordinary purposes.

New 750,000,000 Gal. Water Supply for Ford Plant

Work has been started on a 2¼ mile water tunnel from the Detroit River to the Ford Motor Co. plant at Rouge, Dearborn, Mich., to supply the expanding needs of the plant with 500,000 gal. of water a minute. This volume is 100,000 gal. a minute more than present supply which is now withdrawn from the Rouge River through the slip, the docking place for Ford ships. Ninety per cent of all the water is used for cooling purposes. This is heated up and returned to the lower Rouge River below the plant through a discharge tunnel.

The increased demand for water for manufacturing purposes followed adoption of plans for doubling the capacity of the power plant, with provisions for further anticipated expansion. Several power plant units are now being replaced by two 110,000 kw. turbine-generators, each of which alone requires 150,000 gal. of water a minute for condenser cooling.

The new tunnel, to be completed in a year, is of the gravity type and is being laid 40 ft. underground. Its inside diameter is 15 ft., and it is to have a concrete lining 25½ in. thick.

Present requirements are approximately four to six times greater than supplied by the upper Rouge River. Therefore, the balance must be drawn from the lower Rouge River which reverses the current from the discharge tunnel to the slip. This returns the warm discharge water to the slip and the constant recirculation raises the temperature 18 or 20 degrees above the average river temperature.

To overcome that objection and also to provide for adequate quantities for further expansion the company was faced with the necessity either of tapping the Rouge farther upstream and installing a cooling spray or to tap other sources. By tapping the Detroit River, more than two miles away, the company is assured of unlimited supply and will be able to use its present River Rouge system for disposal of water after having passed through the plant.

New Methods and Equipment in Filtration Plant Operation

Problems Discusssed at the Ohio Conference on Water Purification

SEVERAL new methods or new equipment were described at the 8th annual Ohio Conference on Water Purification. The discussion of one of these "The Use of Carbon Dioxide Scrubber Water for Removing Sand Incrustation," brought out some entirely new ideas on recarbonation. The notes following are taken from the recently issued report of the conference.

Use of Pulverized Quick Lime at Portsmouth

By F. E. SHEEHAN
Superintendent of Filtration, Portsmouth, O.

Lime is used at Portsmouth ordinarily to keep the carbon dioxide content down to a minimum. However, during the last few years, the phenol taste trouble has compelled us to abandon chlorine treatment for days and weeks at a time and during these periods, it has been necessary to resort to excess lime treatment to maintain a factor of safety. To obtain a causticity of about 5 p. p. m., from 2.3 to 2.5 g. p. g. CaO must be used, and with a pumpage of 7,000,000 gal. per day, this amounts to about 2500 lb. of burnt lime or 3500 lb. of hydrated lime.

Lime was first used in the hydrated form in solution feed, but the annoyance of mixing so often and the resultant dust that covered the plant caused us to resort to dryfeed machines, exclusively. In connection with these machines, large hoppers were built, from which the lime was fed to the machines. The use of hydrated lime in these hoppers was not a success as the lime occasionally arched in the hopper and did not feed at all or at other times it fed too rapidly and overflowed the machines. Accordingly we changed to the use of pebble lime which had just come upon the market. In doing so, we added a mechanical slaker. The lime dryfeeds were placed over cylindrical cast iron chambers in the centre of which were set vertical paddles. By means of bevel gears, these paddles were operated from the countershaft which ran the dryfeed machines. The pebble lime worked excellently in the hoppers and slaked quickly, but great difficulty was encountered from the insoluble cores. When large amounts of lime were fed, these cores would collect in the bottom of the slaker and stop the agitator. Accordingly we tried a car of ground burnt lime and the latter, at any rate for small plants, appears to satisfy any demand placed upon it. Shipped in either 180 lb. steel containers or 90 lb. paper-lined burlap sacks, it retains its CaO content indefinitely. Shipped in this manner, it is much easier to unload than hydrated lime which comes in 50 lb. paper sacks, the latter being easily torn and a constant source of lime dust. The ground lime is fed by the dryfeed machines as perfectly as alum, showing no tendency to arch in the hoppers or to overflow. There is apparently no need of assisting the slaking action as the lime almost immediately forms a milk of lime solution in the mixer, comparable to the action of hydrated lime used under similar circumstances. There is no heat developed when small amounts are used, but chemical tests show that no part of the lime is lost through incomplete reaction. I believe it may be used in place of hydrated lime without using elaborate equipment for slaking purposes. The cost of ground quicklime on a unit basis is somewhat less than hydrated lime. All things considered, I believe it to be the most satisfactory manner in which lime may be employed.

Discussion.—The idea that quicklime could be hydrated or put into solution quickly without evolving considerable heat was new to most of the conference members. No appreciable amount of heat is developed in the slaking process at Portsmouth where the lime is discharged into a small solution tank and from which it flows almost immediately to the mixing chambers through approximately 100 ft. of pipe. Mr. Hoover stated that the pulverized quicklime was not the only kind of lime which would slake in this way. He mentioned a kind of crushed quicklime which, after 30 minutes stirring in cold water, goes to pieces with no heat evolved.

A Small Sand Washer and Gravel Grader

By F. E. SHEEHAN
Superintendent of Filtration, Portsmouth, O.

During the last few years, all of the filter units at Portsmouth have been completely overhauled. This has been in connection with the removal of air pipes from the filters and the making of slight changes in the underdrain system to enable us to obtain a higher rate of wash. The overhauling presented no serious problem with the exception of the grading of the gravel before replacing in the filter. The sand was merely ejected to a platform and injected back into the filter. The screening and grading of the gravel by hand, however, was a slow and tedious job, and we looked about for some means of mechanical screening. After experimenting, we finally put together a shaker screen that has successfully handled the gravel from the filters. It consists of a series of screens—2 ft. by 3 ft.—mounted one above the other with the coarse screen at the top and the set of screens as a unit, suspended to swing sideways in a wooden frame. By means of an eccentric arm working from a countershaft, operated by a 3 h. p. motor, the screen was shaken about 250 times per minute and the different sizes of gravel led to separate piles by means of chutes. This shaker has done the work well, but to obtain a successful separation, the gravel had to be perfectly dry. About one-half the gravel can be ejected upon the platform. The remainder has to be shoveled out of the filter, wheeled to the platform, washed, and allowed to dry.

The idea occurred to the engineer of a concern which manufactured sand-screening machinery, who happened to watch our makeshift shaker in operation that use could be found for a self-contained unit for washing and screening filter gravel and, accordingly, he drew up a design for such a unit.

The outfit consists of a revolving screen with central shaft, operated at a speed of about 15 r. p. m., a 2 h. p. motor furnishing the power and a planetary speed reducer producing the low speed, all mounted on a structural steel frame. The gravel may either be injected or shoveled into a scrubbing chamber which is perforated to allow the sand, which is always present in small amounts, to be removed from the gravel. The sand and possibly some of the smaller sizes of gravel pass from the scrubbing chamber to the sand jacket which contains small perforations to allow the sand to pass to the collecting chamber beneath the screen. This tank also catches the dirty wash-water which may be led to the sewer from the tank by means of an overflow nozzle at top of tank. The sand is continually removed from the tank by means of a drag-line, with chain and sprocket drive operated also by the driving motor. The gravel passes from the scrubbing chamber and the sand jacket to the screen proper, which may contain three or four sections or as many as desired, depending upon the gravel to be screened and the number of sizes required. The different sizes may be led from the screen into separate piles by means of chutes.

The entire outfit, mounted on trucks, may be moved easily, in fact it could

be set up near a filter, and the entire gravel content could be removed, washed, graded and returned to the filter in a day's time. The machine, as described, will handle about 100 yds. of gravel in a day. It appears that, since periodic overhauling of filters is absolutely necessary, such a unit as the one described could well be an integral part of the modern water purification plant.

Experiment on Using Broken Stone Instead of Gravel in Filter Bottoms

By O. F. SCHOEPPLE
Chemist-in-Charge, Sandusky, O.

One of the filters at the Sandusky plant gave some little trouble with a very uneven distribution of wash water, the development of hard spots and inversion of sand and gravel. In checking over the filter material in this unit it was found that there was but 9 in. of gravel of which only 2 in. was of a size greater than ½ in. Some little difficulty was experienced in finding nearby satisfactory gravel in the larger sizes. This suggested the use of limestone.

Before it was decided to increase the gravel depth by the use of limestone in the filter bottom an inspection of the crushed limestone in the bottoms of the sewage filters at the Ohio Soldiers and Sailors Home at Sandusky was made. This stone has been in place for something like 30 years and inspection of it indicated that it was in practically the same condition as when placed.

In the large limestone quarries just south of Sandusky are found several grades of limestone all of dolomitic character but differing considerably in hardness. The type selected for this experiment was the same grade that was used on the Akron sewage plant work. The size used was 2½ in.

One filter was reconstructed for experimental work and 4 in. of 2½ in. hard dolomitic limestone was used on the New York Continental Jewel filter bottom. On this stone was placed the original gravel and then the filter sand.

This reconstructed filter was placed in service on June 12, 1928, and to date has given no trouble with gravel inversion. It has developed no hard spots and shows a very even distribution of wash water. No examination of the stone in the filter bottom has been made to date. It is expected to take samples of the stone every year for comparison with the condition of the original stone when added.

Discussion.—The specification calling for round gravel in preference to irregular shaped crushed rock in filter bottoms are wrong in his opinion Mr. Burgess stated. The irregular particles become bedded, and upon examination you can find that in many cases they have not moved after a filter is washed. He cited the case at Wilmington, Dela., where irregular shaped rock was used in the filter bottoms because they would stay in place better than the round gravel.

Smith reported that crushed stone had been in place in the filters at the Lima State Hospital filter plant for two or three years. The rock was put in when, in overhauling the filters, it was decided to increase the depth of the gravel. As no gravel was immediately available some crushed stone was used. Very good distribution of wash water has been obtained since.

If the use of crushed limestone proves to be satisfactory for replacing the larger sizes of gravel in filters it will go a long way toward solving the problem of obtaining satisfactory supporting material for the sand at many places in Ohio.

Use of Carbon Dioxide Scrubber Water for Removing Sand Incrustation

By J. M. MONTGOMERY
Superintendent of Waterworks, Piqua, O.

THE method of treatment of the water supply at Piqua was described in full at the Seventh Annual Conference. It will be remembered that following the heavy lime treatment, the water is treated with carbon dioxide so as to reduce all the hydrate and part of the carbonate alkalinity to bicarbonates. That is, a considerable amount of carbonate alkalinity is left in the water influent to the filters. This, of course, has resulted in some incrustation of the sand.

The carbon dioxide plant consists of a coke burning furnace, a scrubber and drier and a compressor to force the gas through a grid system in the carbonation chamber. Water used in scrubbing the gas has been run to waste until recently when the idea was conceived of passing this scrubber water through one of the idle filters, for the purpose of removing the incrustation from the sand. The scrubber water is highly charged with carbon dioxide and it contains some sulphuric acid which also aids in removing the incrustation. It is introduced into the underdrains of the filter and allowed to pass up through the sand and into the wash water troughs and to waste. The alkalinity of some samples of this scrubber water after it passed through the filter has been as high as 1000 p. p. m. This shows that it is removing the incrustation. Unfortunately insufficient analytical data are available to tell just what can be accomplished, and for this reason it is not known whether it is more economical to treat the sand in this manner or to allow the incrustation to accumulate for several years and to then replace the sand. That problem will be worked out.

Discussion.—Considerable interest was manifest in Mr. Montgomery's description of his method of removing incrustation from sand. Mr. Woodward of the Carnegie Steel Co., raised the question as to whether this method of treatment would remove magnesium carbonate incrustation as readily as it would calcium carbonate. Mr. Montgomery replied that the heavy lime treatment employing 40 p. p. m. causticity precipitated practically all the magnesium in the form of magnesium oxide, which is very flocculent, and in character very similar to alum floc. There is very little magnesium left in the water which can incrust the sand. Mr. Cameron inquired as to the corrosive action of the scrubber water on the piping in the underdrain system of the filter. It seemed to be the opinion of many present that undoubtedly some trouble might result from this practice of introducing scrubber water into the underdrain system of a filter, especially if the scrubber water contained much sulphur. Sulphur can be very largely removed from the scrubber water by replacing the coke in the scrubber with limestone. It is planned, Mr. Montgomery said, to put limestone in the scrubber to remove the sulphur gases. Mr. Hoover, in summing up the points brought out by the paper, and in the discussion, said that he feared that we were getting away from the original purpose of recarbonation. The original purpose was to prevent incrustation. The next development was to over-treat the water with lime, and then apply only enough carbon dioxide to reduce hydrate alkalinity, but leaving normal carbonates in the water. This method of treatment still leaves the water in an unstable condition, and causes incrustation of the filter sand. If it is desired to obtain low alkalinities in the recarbonated water, he said, carbon dioxide treatment should be carried out in two stages; the first application should be at a point near the outlet of the mixing chamber. The quantity should be just sufficient to precipitate magnesium which is flocculent and will carry down the finely precipitated calcium carbonate. The second point of application should be at the end of the settling basins just before filtration. A water treated in this way will have a low alkalinity and will not incrust the filter sand.

Mr. Clark commented on the idea of double recarbonation by saying that in the design of the new water purification and softening plant at Fremont, provision had been made for three points of application for carbon dioxide. The first point is between the clarifier and the sedimentation basin, hoping by application of carbon dioxide there to obtain better deposition of the precipitate formed. The second point is in the regular recarbonation chamber between the sedimentation basins and the filters. A third point of application has been provided in the clear well. However, Mr. Clark stated that he questioned how

far treatment at this point was desirable or necessary.

Regarding the concentration of carbon dioxide in the gas used in various recarbonation plants, the question was asked as to what was the thought underlying the higher concentration of carbon dioxide. It was answered by Mr. Hoover as follows: "We have at Columbus an air compressor which pumps 800 cu. ft. of gas per minute. If this gas contained only 5 per cent carbon dioxide instead of 20 per cent, it would be necessary that we have a compressor of four times the capacity. In other words one which consumes four times as much power."

Liability for Water Borne Diseases

Courts have held on numerous occasions that the owner of a water supply, whether a municipal or private concern, was liable for damages caused by sickness resulting from the use of a polluted water furnished by him. The following synopsis of such decisions was given in an appendix to the final report of the committee on Cross-Connections of the New England Water Works Association:

Green v. Ashland Water Co. (1898) 101 Wis. 258: "If defendant knew, or from the situation ought to have known, the water it is distributing was dangerous for domestic use, from some cause not discoverable ordinarily by the exercise of reasonable care, it owed the duty to its customers of disclosing that danger, and a failure so to do, knowing that such customers were liable to use the water through ignorance of its character, was a fraud in law, rendering the defendant liable to legal damages to any person injured by such fraud without fault on his part, and it was also a failure of duty amounting to actionable negligence as well, to which the same liability is incident." Five thousand dollars verdict involved.

Lockwood v. Dover (1905) 73 N. H. 209: Negligence was alleged in that defendant municipal corporation failed to clean out its water pipes or to provide means whereby they could be cleaned out, and that in consequence thereof foreign and decayed matter became lodged in the city's pipes, entered the pipes leading to the plaintiff's dwelling and was there drunk by the plaintiff's intestate, causing him to sicken and die. It was held that the defendant was liable.

East Grand Forks v. Luck (1906) 97 Minn. 373: Based upon a study of the following cases: Reed v. City of Anoka, 85 Minn. 294, 88 N. W. 981; Walla Walla City v. Walla Walla Water Co., 172 U. S. 1, 19 Sup. Ct. 77, 43 L. Ed. 341; Illinois Trust & Savings Bank Co. v. Arkansas, 76 Fed. 271, 22 C. C. A. 171, 34 L. R. A. 518, Judge Elliot said: "When the municipality enters the field of ordinary private business, it does not exercise governmental powers. Its purpose is not to govern the inhabitants, but to make for them and itself private benefit. As far as the nature of the powers exercised is concerned, it is immaterial whether the city owns the plant and sells the water, or contracts with a private corporation to supply the water. It is not in either case, exercising a municipal function. . . . When a municipality engages in a private enterprise for profit, it should have the same rights and be subject to the same liabilities as private corporations or individuals.

Keever v. Mankato (1910) 113 Minn. 55: "When a municipality voluntarily engages in selling and distributing water to customers for its local advantage or profit, it enters the field of ordinary private business, and has the same rights and is subject to the same liabilities as private corporations or individuals with respect to damages from impurity of the water. . . . It is obvious that a sound public policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water. Nor does it appear why the citizens should be deprived of the stimulating effects of the fear of liability on the energy and care of its officials; nor why a city should be exempt from liability while a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged. Five thousand dollars awarded.

Jones v. Mount Holly Water Co. (1915) 87 N. J. L. 106: "Water is a necessity of life, and one who undertakes to trade in it and supply customers . . . is bound to use reasonable care to see that whatever is supplied for drink . . . shall be reasonably pure and wholesome, and that negligently furnishing water which is deleterious to that human body or health will furnish a valid cause of action to a customer injured by the use of the water." "Actual notice or knowledge of the unwholesomeness of the water of the defendant company was not an essential element to be proven in order to establish the defendant's liability; it was sufficient if there was testimony tending to show that the defendant, in the exercise of reasonable care, might have discovered the unwholesomeness and dangerous condition of the water." Seven hundred fifty dollars awarded.

Vennen v. New Dells Lumber Co. 154 N. W. 640: The facts in the case were briefly these: The employing company had a dual water supply in its factory; one source obtained from the city mains, the other from a nearby stream which was badly polluted. The two water distribution systems were connected by a pipe in the boiler room protected by a Globe valve reinforced by a check valve set against the polluted supply. A number of employees were in the habit of obtaining drinking water from a faucet in the boiler room which was located so that the polluted river water could reach it. Subsequent to the epidemic of 13 cases of typhoid fever and two deaths, the valves were examined and found leaky. The court held on the demurrer of the defendant that typhoid fever was a compensable accidental injury. Sued for $20,000.

It is significant that in another case—Alex Vander Leest v. John Hobert Company, Industrial Commission of Wisconsin Workmen's Compensation 10th Annual Report, July 1, 1921 to June 30, 1922, page 59 it was held by the Industrial Commission that compensation was due nineteen employees of the company who had contracted typhoid fever by use of water from a polluted well of the company. This case, however, was not carried into the courts. Compensation awarded $2,233.61, medical aid $1,742.94. Total $3,976.55.

Stubbs v. City of Rochester (1919) 226 N. Y. 516: One seeking to hold a city liable for injury by typhoid fever, alleged to have been contracted from defendant's polluted water system, is not bound to eliminate all other possible causes of the disease to establish defendant's liability. That a city's contaminated water supply was the source of typhoid fever in a citizen may be found from the fact that he drank water near the point of contamination, that some sixty (60) other cases developed in that vicinity, that his habits were such as to tend to exclude another probable source, while his physician testified that such contamination was the source of his illness.

Canavan v. City of Mechanicsville, 128 N. E. 882: A private water company or a municipality is not an insurer, nor liable as a guarantor, of the quality of the water it furnishes to its customers by the customary means of pipes and faucets, and cannot be held liable for injuries caused by impure water furnished by it unless it knew or ought to have known of the impurity. Its duty is that of exercising reasonable and commensurate care and diligence in providing an adequate supply of wholesome water at all times.

In the case above cited the court decided that the complaint stated a valid cause of action against the defendant city on account of typhoid fever contracted by plaintiff and his children from drinking impure water.

Roscoe v. City of Everett, 239 Pacific 831: In discussing the case the court said: "It is sufficient to say that the evidence discloses that on April 11, 1923, a six-inch main was laid to connect two laterals, and that when the connection was so made it permitted free circulation of water to the city users in the district served, and also better service to the Eclipse Mill Company. At the time this connection was made, there was a by-pass which had existed for a great many years. With the making of the connection there was no longer any need for the by-pass. This by-pass had in it what is known as a gate value A—a valve worked by hand, and which when closed, effectually prevented water from passing through the pipe." . . . "There was evidence that the city never inspected the valve in the by-pass from the date of its installation." . . . "The case with which the valve could be sealed or by-pass removed and the eminent danger to be apprehended by failure so to do are strong factors in the question of the city's negligence." Award $60,000.

Water Company Gives Prizes to Employees for Suggestions Improving Service

Henry W. Drury is the winner for 1929 of the prize of $200 in gold awarded annually to an employe of the Hackensack Water Co., Weehawken, N. J., for the best suggestions to improve service, it is announced by the president of the company, Nicholas S. Hill, Jr.

Four suggestions made by Mr. Drury, who is the commercial agent of the company, have been adopted by the company's departmental heads as the basis of new and better practice.

One of Mr. Drury's proposals was that plumbers be permitted to set and reset meters on customers' services. This has been approved by the Master Plumbers' Association.

Substitution of a simpler form of office record of the establishment of service than the present customers' application blank was another suggestion, which is now being worked out.

A third suggestion was that a simple system of customers' credit rating be established, and that the system of collection of accounts be rebuilt around this rating to the end that collectors' calls may be eventually eliminated. Rating is now well under way, and the result has been better collections with less calls and improved public relations.

Fourthly, Mr. Drury proposed the simplification of the inspection of new meter installations by meter readers.

These suggestions were among many submitted by other employes to the bureau of new ideas, established by the company about three years ago as a part of a general program of service betterment. Previous suggestions, according to Mr. Hill, have proved of great value to the company and to the public.

"All employes were requested to make suggestions which, in their judgment, would increase efficiency of operation and extend the usefulness of the company," Mr. Hill explained. "The response has been both emphatic and enlightening. This year many of the suggestions were so meritorious that the selection of the best was no easy task.

"The bureau of new ideas is developing as a constructive force in anticipating the water supply needs of Bergen and North Hudson Counties. Its operation means increased vigilance on the part of the entire organization of the Hackensack Water Company in the public interest."

Encouraging Watering of Trees.—In an attempt to encourage residents of Kearney, Neb., to preserve their trees, the city water works cut the excess water rate in half for the month of September.

The New Sewage Disposal Works of Highlands, New Jersey

Design and Construction Features of Plant for Fluctuating Load of 2,500 to 15,000 People

By LESTER H. BURNS

ON the Sandy Hook Bay, just north of the Navesink River, lies a range of hills overlooking the Atlantic Ocean. This range of hills colloquially referred to as the "Highlands," is the highest point on the Atlantic Ocean between Maine and Florida. The entire section, combining its wide, sandy beaches and the exhilarating salt sea air with the restfulness of wooded slopes, has been generously favored by Nature. Small wonder, that each year hundreds of thousands of people are attracted from the congestion of the nearby cities to enjoy the beauty of the "Highlands" and the healthful recreations which they offer.

These great numbers of people coming during the short summer season greatly overtax the facilities of the section for administering to the elementary needs of the normal population. During this annual influx of summer visitors, many problems face the governing bodies of the towns comprising the "Highlands." The most pressing question at present is the proper disposal of waste and the elimination of the pollution suffered by the beaches and surrounding waters. This problem is a result of antiquated sewage systems.

The taxpayers of the "Highlands" towns realize that the evils resulting from water pollution will cause serious economic losses if left unchecked; and they realize that these conditions must be changed. As a result, new sanitary systems are being installed to treat this waste by the most modern and approved methods of sewage disposal.

The Borough of Highlands, N. J., by the installation of a modern, well equipped sewage disposal works, designed by Remington & Vosbury, consulting engineers of Camden, N. J., is the most recent town in the ever-growing chain of communities that have taken steps to eliminate the noxious conditions, the result of the old methods of sewage disposal. The system under construction has been designed to meet not only the requirements of the normal population of 2,500, but also the needs of a transient population, which during the summer season reaches a total approximating 15,000 people.

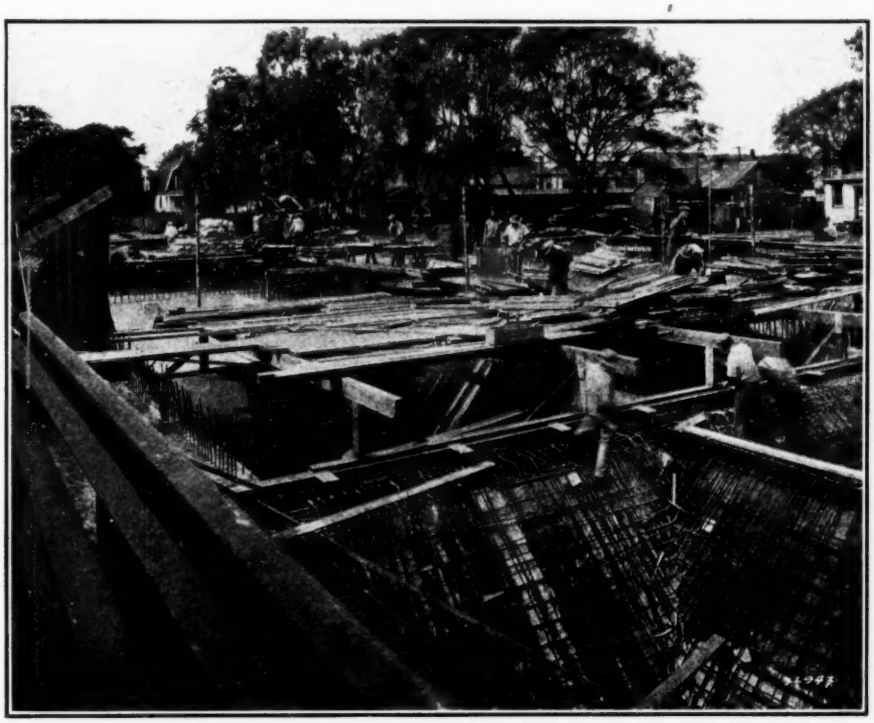
The contract for the construction of the system was awarded to Mahlon Averill, general contractor of Newark, N. J. The construction is under the supervision of B. B. Skinner, and the engineer is Mr. MacDonald of Remington and Vosbury. When completed, the entire disposal plant will embody all the refinements which modern engineering skill has developed. The gravity septic tank principle will be employed to treat the waste.

General Features of Plant.—The system consists of the old network of sewers, which carry the influent to two small pump houses at either end of the town. From these points it is pumped through a 20-in. main leading to the disposal plant, which consists of a large pump house and four septic tanks of four hoppers each, where the waste is treated.

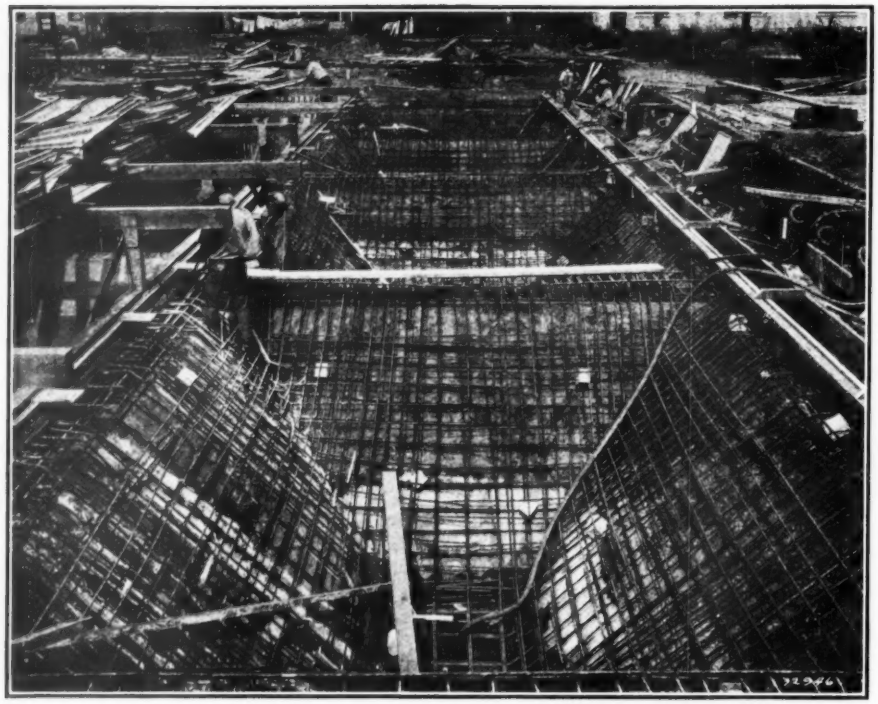
As is usual in residential towns within commuting distance of large industrial centers, the rate of flow in the sewers has definite hourly variations. This factor was given very serious consideration by the designers of the plant. To meet conditions, automatically controlled pumps will be installed in the main pump house to conform to the rate of flow in the sewers. These pumps, two in number, will have different capacities, and both will be the variable-speed type. The smaller pump has a minimum capacity of 200 g.p.m., which can be automatically increased in steps of 100 g.p.m., to a maximum capacity of 800 g.p.m. The larger of the two pumps will have a minimum capacity of 600 g.p.m., with a variable capacity by which the rate of flow can also be increased in steps of 100 g.p.m. to a maximum capacity of 1,200 g.p.m. Both pumps will have a depth increment of 3 in. against a 20-ft. head and will be controlled by variable-speed motors.

Automatic Control.—To effect economy in operation, the motors will be automatically controlled by a float in the sewers, and will require the attention of only one attendant, whose main duties will be to care for the moving parts, keeping them greased, oiled, and in good working condition.

When the influent reaches the main pump house, it is pumped to the hoppers of the septic tanks, through sherrardized V-notch weirs. Automatic valves control the amount of influent which each septic tank will receive, and will prevent the overloading of the tanks nearest to the pumps by the even distribution which they will effect. Once in the septic tanks, the sludge settles by gravity to the bottoms of the hoppers, whence it is pumped to the sludge drying beds above. In each hopper is sludge handling equipment for



General View of Construction Operations for Sewage Disposal Plant of Highlands, N. J.



View of Excavation Showing ¾-in. Steel Reinforcing for Sludge Hopper Construction

pumping the sludge to the drying beds above. This consists of a footpiece having a capacity of 300 g.p.m. of sludge, with a pipe submergence of 14 ft. and a total lift of 20 ft. The air consumption for lifting the sludge will be approximately 2 cu. ft. of air per cubic foot of sludge, but will not exceed this figure. The sludge equipment will be operated by a self-contained motor, operating a 3-in. portable diaphragm pump. Each sludge pump will be surmounted by a cast iron bell to effect an even distribution of the sludge over the sludge drying beds.

The sludge drying beds will consist of a layer of hard, durable, rounded gravel of high specific gravity, and on top of this will be placed a layer of clean sand of .30 to .50 millimeters, with a uniformity and coefficient of 3.50. The underdrain of these beds will be constructed of 8-in. glazed terra cotta half-tile connected to a cast iron drain, to allow the liquid from the drying sludge to flow into the effluent in the septic tanks.

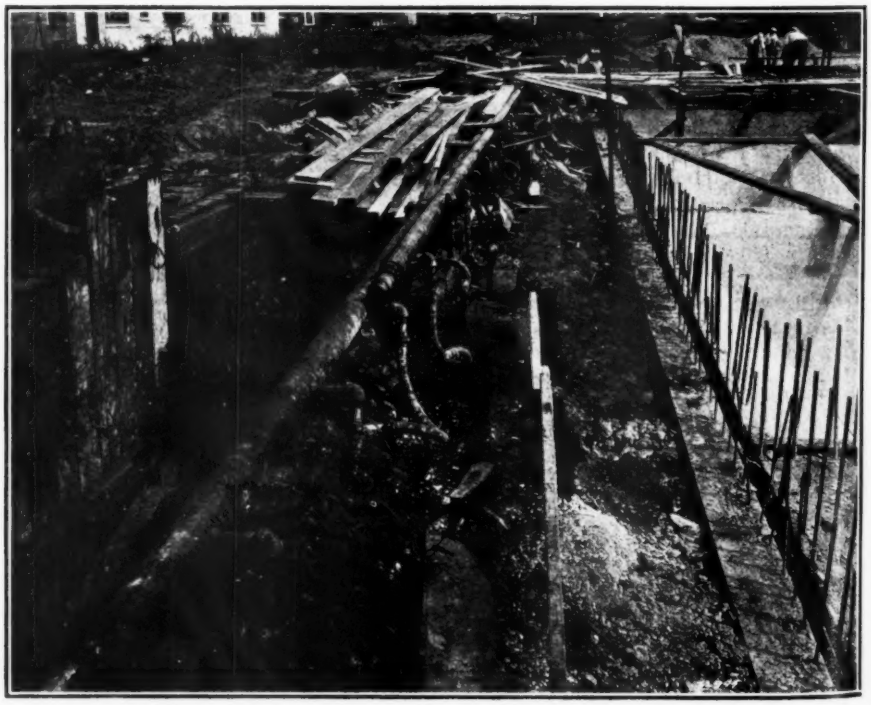
The effluent will flow by gravity from the septic tanks through a vacuum solution manual feed chlorinator, having a maximum capacity of 200 lb. and a minimum capacity of 20 lb. per 20 hours. From the chlorinator it will flow through a 16-in. main to the outfall in the ocean—a distance of approximately 3,000 ft. To clear the channel of the Navesink River, which lies between the plant and the outfall in the ocean, the sewer will have a drop and rise of 25 ft.

The superstructure of the main plant will be of greenhouse construction to allow plenty of light and air for drying the sludge in the sludge beds.

Handling Excavation in Wet Ground.—In the construction of the septic tanks and main pump house, difficulty was experienced in keeping the excavations free of water. This was due to the proximity of the plant to the ocean and the formation of the soil. The top layer, from plus 4 ft. to minus 1.5 ft., consists of an old marsh with many fibrous roots. This layer cuts easily and remains firm after cutting. At minus 1.5 ft., clean, coarse sand is encountered fairly free from water at this point, but becoming more waterbearing down to minus 6.25 ft. Here the marl, because of its hardness and consistency, does not allow the water to drain off, and, as a consequence, forms a pocket for the water. This condition makes the lower part of the sand layer very wet; hence when excavations reached this point, the wet sand, with its tendency to slide, was a constant threat to the sides of the excavations.

Before actual digging started, a large sump hole was dug at the highest level of the ground, outside the foundation limits, to prevent the surface water from draining into the excavations. To keep the excavations as dry as possible, once digging started, 130 well points were driven with a water jet to minus 14 ft. The well points were spaced on 3 ft. centers and 4 ft. outside the foundation limits. They were connected to a 5-in. header by flexible hose. A Marlow centrifugal pump, having a capacity of 500 g.p.m. and operated by a 12-hp. Le Roy motor, was in turn connected to the header. The prime for this pump was maintained by a Marlow 3-in. diaphragm pump. The arrangement kept the excavations fairly free of water.

Prior to excavating for the hoppers of the septic tanks, 25-ft. piling with 10-in. butts was driven to minus 22.5 ft. The piling was yellow pine, calculated for a load of 10 tons. For each hopper 22 piles were driven with a drop hammer. The piling drove easily until the marl was reached at minus 6.25 ft., and from that point the driving slowed up noticeably because of the hardness of the marl. A water jet with a pressure of 100 lb. was tried as an aid to driving the piling, but this proved to



The 5-in. Header and Well Point Connections for Dewatering Operation

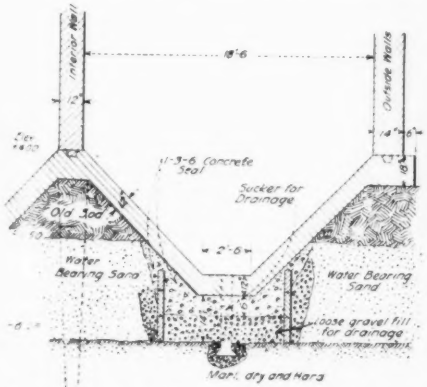
be of little aid in penetrating the marl. As a result, the piling was driven dry.

As the excavating proceeded to a depth of minus 6.25 ft., no serious trouble was encountered; but when digging went beyond that depth, the sand still contained enough water to give serious trouble. The pumps, working continuously night and day for four weeks, could not remove this difficulty, as a consequence the sand, still fairly wet, had a tendency to slide into the bottoms of the excavations.

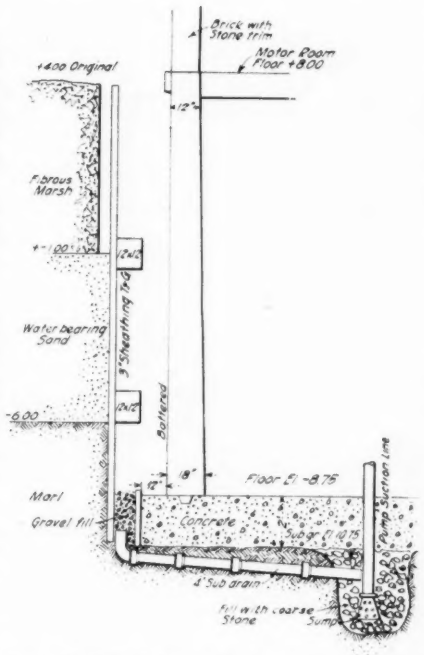
Method of Preventing Wet Sand Seepage.—To overcome this sliding action, several methods were employed, all proving more or less unsatisfactory until the expedient of using gravel was tried. In the pump house excavation, where a vertical cut was required, sheeting could be used, but on account of the 45 deg. angle of the hoppers, sheeting could not be employed here, and the problem of keeping the wet sand in place was more difficult.

For the pump house, 3x12 tongue-and-groove sheeting was driven to minus 14 ft., 2 ft. deeper than the cellar bottom. This sheeting was driven for a distance of 8 ft. through the hard marl with an Ingersoll-Rand CC-35 sheet pile drive, the air for which was supplied by an Ingersoll-Rand portable compressor. At minus 12 ft. the cellar bottom was reached, but in spite of the fact that the sheeting went to minus 14, the wet sand kept slowly oozing through. To stop this seepage, a 1-ft. trench was dug along the inside of the sheeting and was filled with gravel. A 4-in. sub-drain ran from the gravel to the center of the excavation, where it emptied into a sump hole. A suction line connected to a centrifugal pump was placed in the sump hole and then the hole was filled with gravel. This method succeeded in keeping the cellar bottom free from water.

Preventing Sliding of Wet Sand.—Obviously, because of the dissimilarity in construction, an entirely different method had to be devised, for stopping the sliding action of the wet sand in the hoppers. The method finally decided upon by Mr. Skinner, which proved successful, consisted in making a hole 2 ft. deep and 6 ft. across at



Cross Section of Hoppers in Septic Tank Showing Method of Sealing Bottoms



Cross Section of Pump House Foundation Showing Method of Draining Cellar Bottom

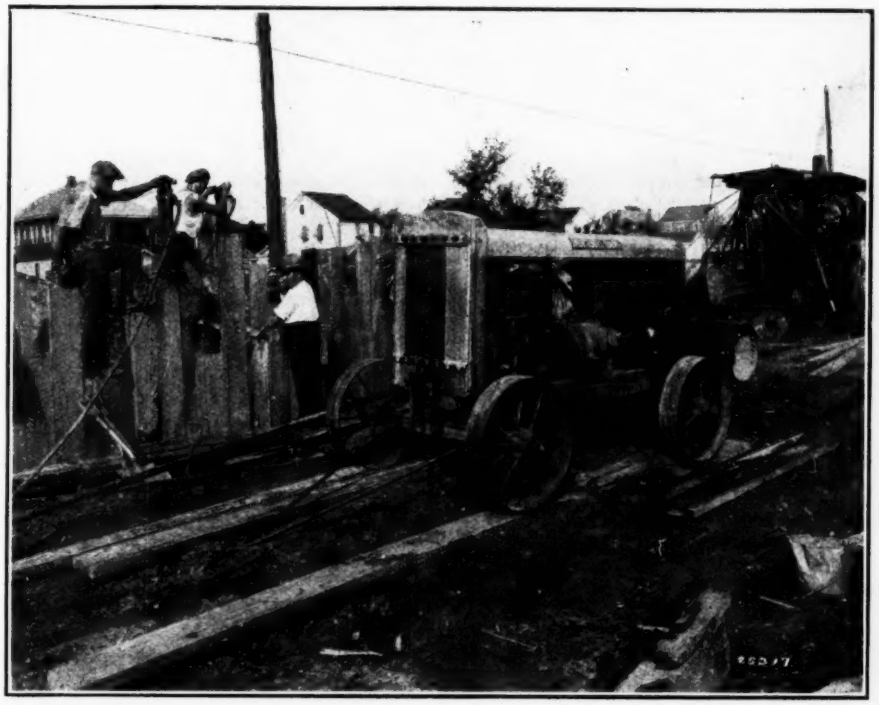
the bottom of each hopper. The sides of this hole were lined with 2x8 tongue-and-groove sheeting placed on edge, and laid parallel to the bottoms of the hoppers. Shallow holes were dug at the top and back of this sheeting and filled with gravel. As the weight of the gravel caused it to sink, more was added until the gravel extending from the top to the bottom of the sheeting formed a curtain between it and the wet sand.

A sucker line for draining was placed in the center of the hole and gravel to a depth of 6 in. placed around the sucker. The sucker, which operated continuously, drew off the water and kept the water level below the top of the gravel. It was in operation until after the concrete seal had been poured and had set. The seal consisted of a 1:3:6 mixture. It was poured to a depth of 6 in. on the layer of gravel and also along the sides of the hoppers to a height of 1.5 ft.

This seal effectually checked the seepage of the sand and water into the hopper bottoms. Work then proceeded rapidly, as no further difficulty was experienced from seepage. The walls of the hoppers were poured with a 1:2:4 mixture reinforced with steel bars. The weight of the steel used for each hopper averaged 2 tons.

Company Operates 31 Alabama Water Systems.—The Alabama Water Service Co., which recently acquired the properties of the Consumers' Water Co., in Alabama, now operates 31 water works in the states. The Alabama Water Service Co., is a subsidiary of the Federal Water Service Corporation, which through its subsidiaries furnish water for domestic and industrial purposes to numerous cities and towns throughout the country having a total estimated population of more than 2,380,000. Federal's properties are distributing more than 270,000,000 gal. of water a day through 5,350 miles of mains, not including recent purchases.

Some New Jersey Municipalities.—Two municipalities in New Jersey consist of golf courses, one is an airport, another has a population of 10, and a fifth is credited with 12 inhabitants.



Driving Piles with Sheeting Hammers and Portable Compressor

Collection and Utilization of Gases

Economic Phases of Use of Gases from Sewage Sludge

By DR. ANTHONY J. FISCHER
Engineer, The Dorr Co., New York

GASES produced by the digestion of sewage sludge have been collected and utilized since as early as 1907. Up until 1925, however, little thought had been given to the economic aspects of this problem. Then when various investigators demonstrated that with proper temperature and control, digestion capacities could be cut approximately in half there was a renewed interest in the collection of gas for sludge heating.

Amount of Gas Produced.—In general, laboratory experiments have shown that an average American domestic sewage will produce 530 c.c. of gas per gram of dry solids if thoroughly digested. Indications are that various physical and chemical factors do not affect this total production, although they do affect the rate of production. The chief controlling factors are temperature seeding, pH value, stirring, concentration, and character of sewage. Inasmuch as we are interested chiefly in the rate of gas production in actual plant operation, these factors are of vital importance. If, for example, a tank has sufficient capacity to take care of a 60-day supply of raw sludge containing 5 per cent total solids, with 75 per cent volatile matter, we could expect to obtain 90 per cent of the gas, provided we maintain a temperature of about 75° F., a pH value of about 7.5 and an amount of ripe sludge equal to at least 20 times the daily addition of raw slude on a dry solids basis. Lowering the temperature, pH value or amount of ripe sludge will cut down this percentage considerably. Stirring has a beneficial effect and will increase the rate of production.

Comparisons of daily production on a per capita basis mean very little because the amount of gas will vary with the strength of the sewage and the removal of suspended solids by the settling units. Taking an average domestic sewage containing 200 p. p. m. suspended solids, we can safely assume a 50 per cent removal for primary settling only, 75 per cent for a trickling filter plant and 90 per cent for an activated sludge unit. Under proper conditions, therefore, we should obtain a daily gas production of 0.64, 0.96 and 1.15 cu. ft. per capita, depending on the method of treatment.

Composition of Gas.—The composi- of the gas will, of course, vary depending on the character of the sewage. Gas from material high in carbonaceous materials, such as screenings, will give a low methane content. The average gas, however, may be safely assumed to contain about 70 per cent methane, 25 per cent carbon dioxide, and 5 per cent nitrogen. As the heat value of the gas is directly proportional to the methane content, the heat value can be estimated to be 700 B. T. U.'s per cu. ft. This assumes the absence of hydrogen which is present only under abnormal conditions. Other hydrocarbon gases are present in so small amounts as not to have any appreciable effect.

At the present time nearly every tank with gas collection facilities is of the separate digestion type. As a rule, tight concrete covers for these tanks are favored as this type of construction allows covering with earth which is highly desirable during cold weather. They also insure against any loss of gas through leakage. Practically all the covers have a slight slope and have the underside submerged. This has the advantage of preventing the accumulation of gas in the tank and hazard of explosion; it also causes the scum in the tank to be submerged, under which conditions it digests more readily instead of forming a thick hard crust through which the gas has difficulty in escaping.

Gas Collection System. — Modern practice favors a gas collection system consisting of a gas dome, condensation trap, meter, flame trap and pressure relief trap for small installations. For large plants a gas holder might be desirable.

Considerable attention has been paid to the design of gas domes. In general, high separate seal domes are desirable because they prevent the loss of gas if for any reason the liquid level in the digestion tank is lowered, and they also lessen the chances of gas line clogging by scum rising in the dome. German practice favors the use of a scum rack or screen to prevent clogging by scum. It has been found, however, that these racks clog quickly and their use is questionable. The best method of eliminating this troublesome feature of gas collection is by draining off the scum through a line running to the dome. Spraying water through nozzles connected to the gas lines has also been tried, but was found to afford only temporary relief. Whether or not sprays are used, however, there should be connections available for flushing back the gas line between the condensation trap and the gas dome.

In cold climates insulation of the gas line is absolutely necessary; otherwise, freezing of condensate will cause clogging. The condensate should be collected and drained off periodically at the low point in the line before the gas enters the meter.

In order to prevent a possible backflash in the line, a safety flame trap should be provided. This trap should be located between the source of supply, whether it be a gas holder or the digestion tank, and the point of utilization. Two methods of accomplishing this purpose are in use: (1) A water seal, and (2) a wire gauge arrangement similar to a Davy safety lamp. It appears that either of these will afford adequate protection against explosions.

The pressure relief trap should be connected in front of the flame trap. It consists of an ordinary closed tank partially filled with water and connected so that when the gas pressure exceeds the submergence of the entrance pipe, it automatically by-passes through another pipe connected to the top of the tank. This will prevent the building up of pressure in the line should the use of the gas be discontainued. It is also of value where the gas is put to two separate uses, as the amounts sent to each point of utilization can be regulated by varying the submergence of the entrance pipe.

Utilization of Gas.—At the present time in this country, gas is being collected and utilized chiefly for sludge heating. This not only allows more economic construction by cutting the digestion capacity in half, but also does away with odor nuisance. In only one plant is there an attempt being made to heat the sludge in an Imhoff tank. All others are of the separate digestion type. At one plant, not yet in operation, the gases will be used as a source of heat in glass-covered sludge beds to facilitate drying during the winter months; at another, it will be used for burning screenings. In the past, the gas has been used successfully for heating small buildings. This is not being done at present to any great extent.

The use of gas for power has been shown to be entirely feasible by large scale tests. There is a renewed interest in this method of utilization, especially in view of the fact that the gas obtained is more than sufficient to maintain an average yearly temperature of 75° F. At a number of plants where the sewage is pumped, all or a part of the gas will be used for this purpose.

The disposal of activated sludge by digestion has also opened up another field for the use of the gas: that of operating the air compressors. This is already being done at the Sugar Creek plant at Charlotte, N. C. Gas being obtained from the digestion of combined raw and activated sludge amounts to about 30,000 cu. ft. a day and is used to run the compressors for about seven hours each day.

Hatfield estimated that 14 cu. ft. of gas obtained from the Imhoff tanks at Decatur would generate one brake horsepower hour. On this basis, figuring on 1.15 cu. ft. of gas per capita per day, 820 b. h. p. hours could be generated by the digestion of sludge from a contributing population of 10,000 Assuming that the power required for aeration were 25 h. p. per m. g. d., more than enough power would be available. In warm climates there would be a possibility of having sufficient gas both for sludge heating and for aeration.

Acknowledgment.—The above is a paper presented at the 11th Texas Water Works Short School.

Cost of Sewage Works Operations

Data for the Treatment Plant of Baltimore, Md.

By C. E. KEEFER

Engineer of Sewage Disposal, Bureau of Sewers, Baltimore, Md.

THE keeping of accurate and detailed cost data of the maintenance and operation of sewage works is a matter of prime importance for many reasons. These records are of special value to the plant superintendent, as they enable him to compare one year's costs with another. Furthermore, where plans are being considered to replace a portion or all of the plant with other treatment units, a more logical decision can be reached if accurate operating costs are available for study and comparison. These costs serve a wider field if they are published, and thus become available to sewage works superintendents and engineers. In view of these facts it has been the policy for a number of years at the Baltimore sewage works to prepare detailed cost figures. Although the methods followed in keeping these records are essentially the same as for other municipal or private undertaking, the general principles involved will be briefly presented. Tables of segregated costs are given covering the operation of the Baltimore plant.

Generally speaking, there are two items which, when added together, give the total cost of sewage treatment. The first of these is the fixed charges, which include the interest on the original investment and the depreciation of the improvement. The second item, with which the sewage works operator is particularly concerned, covers operating and maintenance costs.

Interest and Depreciation Charges.—The first cost of a plant is usually known at the time it is put into operation. This cost should include not only the money paid contractors for construction expenses but also such items as the cost of the property on which the plant is built, engineering and architects' fees, administrative and overhead expense, discount on the sale of stock, and other preliminary expenses. In case it is impossible to obtain some or all of these expenditures the sewage works operator should prepare an estimate of the total cost of the plant. With this cost established, together with the rate of interest and the par value of the stock, which is sold to finance the project, it is possible to calculate the annual interest charge.

From time to time improvements—perhaps of a minor nature—will be made. The cost of these should be added to the first cost of the plant even though the funds allotted for the work were originally intended for operation and maintenance purposes.

To determine the annual depreciation charge it is necessary to assume some future date when the sewage plant will have to be rebuilt because of obsolescence or because of its deteriorated condition. The progress that has been made during the last five or ten years in sewage treatment would indicate that many sewage works will have to be rebuilt because of obsolescence rather than because their useful life has terminated. For this reason it becomes difficult to estimate depreciation charges. As indicated in Table I the useful life of the Baltimore sewage works has been assumed to be 33⅓ years. A considerable portion of the plant has now been in service for 17 years, and it is believed that a large part of it would give service for another 30 or 40 years. It is likely, however, that future advances in the science of sewage treatment will not justify continuance of the present method of treatment at Baltimore for that length of time. In fact, plans embracing extensive changes are now being prepared.

Calculating Depreciation.—With the useful life decided upon the next procedure consists of selecting the most desirable method to follow in calculating the depreciation. Several ways of determining this charge are available, such as the straight-line method, the diminishing-value plan and the sinking-fund plan. These three methods will not be discussed other than to say that each possesses certain advantages. It would seem most desirable to use the sinking-fund method for determining the depreciation of public improvements. This plan consists of setting aside each year a sum of money so that at the end of a predetermined time—the estimated life of the improvement—the sum total, including the accrued compound interest, will equal the first cost of the project less its scrap value. The annual installment, "I" (depreciation charge) necessary to set aside for a term of "n" years at an interest rate of "i" to provide a sinking fund "S" can be expressed by the formula

$$I=\frac{Si}{(1+i)^n-1}$$

After the fixed charges have been calculated, it then becomes necessary to determine the annual running expenses of the plant.

Operation and Maintenance Charges.—The sewage works superintendent desires to know not only the total cost of operating his works but also the cost of running the various treatment units of the plant. This information can be obtained by assigning charge numbers to each phase of the operation, such as screening, grit removal, sedimentation, oxidation, sludge digestion, sludge drying, and maintenance of grounds. All money expended, both for labor and materials, can then be properly segregated. In order that the segregations may be intelligently made at those plants where electric power units are

Table I—Cost of Sewage Treatment at Baltimore

				Fixed Cost			Operating Cost			Fixed Cost and Operating Cost		
Year (1)	Average Sewage Flow M. G. D. (2)	Population Contributing Sewage[1] (3)	Total Cost of Plant (4)	Interest 4.1% Plus Depreciation 1.5%[2] (5)	Per M. G. of Sewage (6)	Per Capita per Year (7)	Total (8)	Per M. G. of Sewage (9)	Per Capita per Year (10)	Total (11)	Per M. G. of Sewage (12)	Per Capita per Year (13)
1921	46.62	536,952	$3,337,100	$186,877.60	$10.98	$0.348	$ 76,656.02	$4.51	$0.143	$263,533.62	$15.49	$0.491
1922	47.49	556,400	3,344,100	187,269.60	10.80	0.337	106,384.26	6.14	0.191	293,653.86	16.94	0.528
1923	48.17	578,755	3,496,000	195,776.00	11.14	0.338	103,983.21	5.91	0.180	299,759.21	17.05	0.518
1924	53.50	608,127	4,027,600	225,545.60	11.52	0.371	106,945.52	5.46	0.176	332,491.12	16.98	0.547
1925	55.09	647,080	4,257,800	238,436.80	11.86	0.368	108,048.90	5.37	0.167	346,485.70	17.23	0.535
1926	58.54	681,962	4,392,400	245,974.40	11.51	0.361	103,399.73	4.84	0.151	349,374.13	16.35	0.512
1927	59.62	702,827	4,584,000	256,704.00	11.80	0.365	104,418.00	4.80	0.149	361,118.00	16.60	0.514
1928	63.49	714,032	4,601,900	257,706.40	11.09	0.361	107,632.79	4.63	0.151	365,339.19	15.72	0.512

[1] Estimated as of July 1.

[2] Depreciation based on a useful life of 33⅓ years.

Table II—Cost of Operating the Baltimore Sewage Works

No.	Treatment Unit	1921	1922	1923	1924	1925	1926	1927	1928
1.	Bar screens	$ 5,469.19	$ 5,544.34	$ 4,571.48	$ 5,454.52	$ 5,790.73	$ 6,207.70	$ 6,119.19	$ 5,928.62
2.	Settling tanks	8,974.66	11,733.60	16,944.95	17,372.38	17,231.64	16,880.86	18,650.84	21,205.66
3.	Imhoff tanks	4,822.11	3,640.52	3,536.68	2,896.14	.....	.....	.....	.....
4.	Revolving screens	10,987.67	13,289.15	13,518.24	10,694.38	13,171.15	8,809.55	9,184.28	4,898.37
5.	Trickling filters	11,500.72	16,599.40	12,602.55	16,247.69	13,483.48	15,583.68	13,608.66	14,276.39
6.	Final settling basins	3,491.19	3,437.87	4,972.45	5,190.52	4,287.61	3,805.83	4,307.50	3,793.64
7.	Sludge digestion tanks	8,057.62	9,534.16	12,780.20	14,187.11	16,078.24	13,122.31	10,891.97	11,318.71
8.	Sludge drying beds	13,262.19	18,181.37	23,300.63	23,558.90	23,601.03	25,001.21	25,311.14	24,099.49
9.	Final sludge disposal	2,090.67	16,331.68	506.38	.....	.....	2,561.34	4,242.99	7,643.39
10.	Maintenance of grounds	8,000.00*	8,092.17	11,159.65	11,343.88	14,405.02	11,427.25	12,101.43	14,468.52
	Total	76,656.02	106,384.26	103,983.21	106,945.52	108,048.90	103,399.73	104,418.00	107,632.79

* Estimated.

used, wattmeters should be provided to register the power consumption at the various parts of the plant.

It is frequently desirable to keep operation and maintenance costs separate, with each of these items further segregated into labor and materials. Operation charges should include such items as labor required to clean sewage screens, to attend to the operation of settling tanks, to remove sludge from drying beds electric power used to operate sewage and sludge pumps, chlorine used for treatment purposes, chemicals and supplies. Maintenance charges are embraced in such items as labor and materials needed for repairs, the painting of buildings and the storage of materials and supplies.

It is of particular importance that daily records of the quantity of sewage treated be obtained, together with the approximate number of persons served, so that the cost per million gallons of sewage and the cost per capita per year can be calculated. The general character and strength of the raw sewage should be known, as the cost of treatment is dependent thereupon.

It often becomes difficult to decide whether the cost of certain work should be added to the first cost of the plant, or should be included in the maintenance charges. The circumstances surrounding each case must be known before a satisfactory decision can be made. Let it be assumed, for example, that a pump is purchased for handling sludge. If the plant had never been equipped with such a unit, the installation should be classed as a new improvement, and the cost incorporated in the first cost of the plant; if the pump replaces another unit of the same kind because the latter has worn out, the first cost of the plant remains the same and the cost can be charged to depreciation reserve, but if the above replacement were due to the existing pump being damaged, the cost should be added to the maintenance of the plant.

Cost of Operating the Baltimore Sewage Works.—The cost of operating the Baltimore sewage works from 1921 to 1928 is shown in Tables I and II. Table I gives both the fixed and the operating costs on a million gallon and a per capita basis. It is of interest to note that during this period the fixed costs have fluctuated over a narrow range from a minimum of $0.337 to a maximum of $0.371 per capita per year, a variation of about 10 per cent. The per capita operating costs have fluctuated more widely, from $0.143 to $0.191. The operating costs per capita reached a maximum in 1922, and since then they have been decreasing, due chiefly to a greater number of persons being served.

In Table II the costs have been segregrated under ten different headings. These costs, as well as those given in Table I, do not contain any salaries other than paid to the employees at the sewage works. Thus, general overhead is not included. The cost of superintendence, including the salaries of chemists, clerks, foremen, watchmen, and janitors is distributed over the ten items in Table II.

Since the principal item of expense in operating the plant is labor and supervision, the personnel and their salaries are given in Table III. There is usually little fluctuation in the number of employees except in the number of laborers employed to remove sludge from the drying beds and to maintain the ground drying beds and to maintain the grounds. With reference to the former group as many as three gangs are needed at times, with 10 men in a gang, exclusive of the foreman and the operator who drives the locomotive. During the spring and fall, however, one gang is sufficient. The maintenance of the grounds which consists mostly of cutting shrubbery and grass, frequently requires the services of from two to six men.

The cost data compiled at the Baltimore works have been of great value as a basis of comparison with the cost of other methods of sewage treatment, especially where these methods have been considered for adoption at the Baltimore plant. Similar costs, compiled at other sewage works, should prove useful to engineers and others who are interested in sewage treatment.

Acknowledgment.—The foregoing is taken from the July Sewage Works Journal.

Table III—Personnel of the Baltimore Sewage Works

Title	Number Employed	Salary
Supervising force		
Superintendent	1	$2,800 per year
Chemists	4	$1,600 to $2,500 per year
Clerk	1	$1,600 per year
General operating force		
Foreman	1	85 ct. per hour
Operating engineer	1	$1,800 per year
Sewage sampler	1	50 ct. per hour
Storekeeper	1	50 ct. per hour
Janitors	2	30 ct. and 45 ct. per hour
Watchmen*	2	45 ct. per hour
Laborers	12	45 ct. per hour
General maintenance force		
Machinists	2	75 ct. and 80 ct. per hour
Electrician	1	$1,900 per year
Carpenter	1	70 ct. per hour
Chauffeur	1	50 ct. per hour
Helpers, handymen, etc.	5	45 ct. and 50 ct. per hour
Bar screens		
Laborers*	2	50 ct. per hour
Settling and sludge tanks		
Laborers	10	45 ct. and 50 ct. per hour
Revolving screens and trickling filters		
Operating engineers	4	$1,500 to $1,600 per year
Laborers*	2	45 ct. per hour
Sludge drying beds		
Foreman	1	65 ct. per hour
Locomotive operator	1 to 2	50 ct. per hour
Laborers	10 to 22	45 ct. per hour
Final sludge disposal		
Crane operator	1	55 ct. per hour
Maintenance of grounds		
Laborers	2 to 8	45 ct. per hour
Total	69 to 88	

Note: Supervising force works 38½ hours a week. Remainder of personnel works 48 hours a week except as noted.
The salaries paid during 1928 totaled $89,186.55.
*Work 56 hours a week.

Field Chlorination of New and Old Mains

Practice at Baltimore, Md., in Disinfecting Water Pipe

By J. H. STROHMEYER
Assistant Civil Engineer, Water Department, Baltimore, Md.

IN conformity with advanced standards of sanitation generally prevailing, the Bureau of Water Supply, of Baltimore, has been disinfecting water mains immediately after laying and prior to placing them into service. This procedure, the value of which I was at one time skeptical, has been forced upon us by circumstances which indicate quite conclusively the necessity for such sanitary measures.

Five years ago the matter was brought forcefully to my attention when a main laid by a contractor was flushed and gave forth articles which were anything but conducive to purity. It was evident that the pipe, which had laid for six months along the side of an arterial highway, had received but a cursory inspection before installation. Such a condition demanded definite action and our water main chlorination policy was inaugurated at that time.

Contamination of Pipe in Yards and Field.—A number of bacteriological tests were made to determine the probability and extent of contamination in pipe stored in our yards and of pipe distributed in the field. Cultures made from samples taken from the pipe stored in the yard developed generally negative results in both gas formation and excessive counts.

It is a matter of some interest that the cultures from the pipe piled in a north and south direction were generally better than those from pipe piled in the east and west direction. This may have been the result of the first mentioned pipe being exposed to the ultra violet rays of the north light. Because of the numerous buildings in our pipe storage yard causing eddy currents, I am of the opinion that the prevailing winds could have had little bearing on our observed data. The cultures taken from the pipe distributed along the line of its proposed installation and having been exposed to contamination for varying periods of time were found to be almost uniformly bad.

The results of tests of samples taken later at various times corroborate the first findings and indicate that contamination occurs in the field.

Standard Treatment at Baltimore, Md.—A standard treatment was established, which has been carried out as consistently as possible, providing an application of available chlorine of 100 p.p.m. of water. In terms of weight this ratio is 0.6 lb., or 10 oz., of free chlorine per 100 cu. ft. of main volume to be disinfected.

For small mains from 6 to 10 in. in diameter, calcium hypochlorite is applied by the water pipe construction foreman during installation. Since about 33 per cent chlorine is available in this compound, the amount of lime applied is about 2 lb. per 100 cu. ft. Upon completion of construction the main is charged very slowly and allowed to remain so for 24 hours when it is thoroughly flushed.

Under certain conditions, chemical treatment of this type is not practical. For example, a main which has been open in a trench for some period of time and which has accumulated a deposit of mud or other earthy material, requires, first, mechanical purification in the removal of the material either by scraping, flushing or both. In such cases it is impossible for a normal dose of chlorine and water to penetrate the foreign masses. Since these are most likely to be contaminated, the mechanical cleansing becomes practically a necessity before chlorination.

Cost Is Slight.—Chlorine gas, which is obtainable in tanks of portable size, is easily applicable to water main purification. Modern production methods and the great quantities in which it is now manufactured for the use of water works and other trades make its cost reasonable. Whether used in the form of hypochlorite of lime or as a free gas, there is no question in my mind, but that its slight cost is more than justified in the security following its use. It costs 1 ct. a foot to disinfect a water main with hypochlorite of lime and 2 ct. a foot using chlorine gas.

The method of application is arbitrary and matters little so long as effective mixture with the water is obtained. The free gas lends itself very readily to this mixing and for that reason should be given prime consideration when an extensive program of water main purification is being considered.

Methods at Baltimore.—After some years of experimentation a very efficient method was devised and an experimental injector was designed and built at the Bureau of Water Supply in Baltimore. The injector depended upon pressure of chlorine in the cylinder to force the gas into the main. While it worked quite well on several small jobs, it was found that its capacity was not sufficiently great to allow efficient chlorination of greater volumes. Our latest development consists of a mixing valve, a supply hose, a discharge hose and incidental fittings. In detail, the apparatus is arranged as follows: The syphon connection on the mixing valve is attached by a rubber hose to the chlorine cylinder, the supply hose is connected between a corporation cock in the old section of main and the supply end of the mixing valve, a hand valve being inserted in that point to allow adjustment of the flow, the discharge hose carrying the water and chlorine mixture fastened to the discharge side of the mixing valve and the injector tube. The tube is inserted through a corporation cock into the newly laid main.

The operation of the apparatus is very simple. Both corporation cocks are open, the hand valve is opened slightly to allow a small jet of water to flow through the mixing valve; the chlorine valve is opened, after which the hand valve is opened to the fullest extent, creating a noticeable suction on the chlorine supply. The line valve separating the new and old portions of main is raised the desired amount to produce a turbulent flow through the new section. The degree to which this main valve is opened depends upon the size of the flushing orifice at the end of the new section.

Operations Involved.—This method of chlorinating combines three operations, the latter two of which are valuable to purification. The first of these is the initial charging of the main, the other two are flushing and chlorinating, thus combining mechanical and chemical purification. Since the concentration of chlorine of 100 p.p.m. produces a residual chlorine content quite noticeable by odor, a uniform dosage is applied until such time as in the opinion of the operator it has reached the desired ratio. At this time the main valve and the blow-off are both closed, the chlorine tank disconnected, the hand valve on the supply line closed, the injector withdrawn from the corporation cock, which is then closed, and the apparatus thoroughly washed by means of the supply hose. Despite this washing, it is practically impossible to prevent corrosion of the ¾-in. silver plated injector tube, which has to be replaced at frequent intervals. A new type of injector is now being experimented with, which is resistant to, or rather unaffected by, oxidation, it being a glass tube enclosed in a hard rubber or bakelite casing.

The chlorinated water is allowed to remain 24 hours, after which interval the main is thoroughly flushed and placed into service. For definite assurance that the main is free from chlorine, a sample is taken from the blow-

off and tested for free chlorine by the ortho-tolidin or starch iodide method.

Chlorinating Old Mains.—In chlorinating old water mains, our practice is similar to new main chlorination. A section of the old main is removed in order to determine the amount of tuberculation, the types of microscopic growth, and to observe the general physical condition. From this information it is possible to decide upon a course of action which will enable us to purify along the most efficient lines. Personally, I believe that most old mains should be scraped and cleaned before attempting chlorination. However, we seldom find it necessary to chlorinate an old water main.

Sterilization of water mains is not a possibility, or better, not a practicability because of conditions over which the agents have no control. Purification or disinfection is, however, quite possible, since the purpose thereof is the destruction of bacteria pathogenic to man. The degree of disinfection varies with the amount of oxidation which has taken place, which in turn is indexed by the amount of free residual chlorine. Therefore, contrary to what I feel is a more or less popular belief, free residual chlorine does not indicate a sterile main, but serves rather to indicate a factor of safety, since there is no absolute certainty that the chlorine has penetrated every cubic inch of the treated volume.

Table Showing the Amounts of Hypochlorite of Lime Necessary to Disinfect One 12-Ft. Length of Main

Diameter of main in inches	4	6	8	10	12
Ounces of hypochlorite of lime	0.34	0.75	1.33	2.09	3.01
Tablespoonfuls, hypochlorite of lime	½	1	2	3	4

Acknowledgment.—The foregoing is an abstract of a paper presented June 26 at the 49th annual convention of the American Water Works Association.

Odor Control at Sewage Disposal Works

Experiments in 1928 at New Jersey Plant

By JOHN R. DOWNES

Supervising Engineer, The Plainfields and Duncl'en, N. J., Joint Sewage Disposal Works

ODORS naturally divide themselves into two classes: local and migrating. Local odors are such as may emanate from exposed sewage solids about screens or where they may have been carelessly dropped by attendants, or grease cakes forming just above the water line of sedimentation tanks and baking in the hot sun. Such odors and those about small pump stations may be annoying close at hand, but certainly would not be noticeable 50 yards from the source.

Cleanliness and the use of a good deodorant such as Phinotas will overcome local odor difficulty, though care should be taken to choose a deodorant which has an odor not worse than that which we seek to overcome. By this I mean that a good honest ammoniacal, stale urine odor is much preferable to many of the compounds used about public toilets. However, some very pleasing effects may be secured by carefully selecting the proper compounds.

By migrating odors, I mean odors that travel more than 100 yards, and this may stretch to a mile or two under favorable conditions. This type of odor is occasionally carried by high winds, but is then dispersed, within a reasonably short distance, by the very wind that carries it. They become really troublesome under the peculiar atmospheric conditions which produce smoke flags. These conditions most often occur about dusk.

Smoke Flags.—Probably all have noted times when a trail of smoke from a bonfire will hang suspended in the air a definite distance from the ground and from any object which it approaches. The smoke does actually travel in a definite direction, but so slowly that its movement is not visible. Also, which is the crux of the situation, so slowly that it is not broken up by eddies, or dispersed on approaching an object in its path, but flows, ever so gently, around or over such object. Usually, if you observe these smoke flags, you will see that they do not actually touch objects in their path but pass around them at a definite distance. It is this condition which makes shrubbery screens useless as odor controls. When there is wind enough to give obvious movement to the air currents, the odor cloud is broken up by impingement against the shrubbery wall, but without such degree of velocity the screen is ineffective, since the analogous smoke flag is often observed to trail over an intervening forest and descend unbroken on the opposite side.

The chief offending compounds which migrate in this fashion from sewage disposal plants are hydrogen sulphide and its allies. It has been definitely shown that this gas is attacked by chlorine with the formation of substitution products with odors varying from "Medicated" (chloroform) to zero, according to the quantity of chlorine used.

Cost of Odor Control.—While the quantity of chlorine used for this treatment appears large when figured in parts per million, Lynn Enslow and Wm. J. O'Connell, Jr., have developed the idea that the peak of hydrogen sulphide production is almost always coincident with the afternoon peak of sewage flow and it is only necessary to apply chlorine on this peak and possibly during the early evening hours, when there is still some of the offensive gas being carried over from the settling tanks, and when atmospheric conditions are ideal for the formation of smoke flags.

For instance, at the Plainfield plant the rate of use of chlorine is 400 lbs per day, but it is necessary to apply it only during four or five hours with a total daily consumption of 70 lbs. Under these conditions, and with chlorine procurable at 6c per pound the cost for odor control during six summer months approximates $700.

We treat only during the summer months because hydrogen sulphide is produced in troublesome quantities only during warm weather.

Odor Control by Partial Activation.—Treating 25 per cent of the settling tank effluent by the activated sludge process and then mixing this treated portion with the balance of the tank effluent, very effectively destroys the hydrogen sulphide odor. From the operator's point of view, this method is preferable to chlorine treatment, but even though we can secure our power free by making use of the gas from the digestion tanks, the carrying charges on the machinery installation for the activated sludge process, are greater than the cost of chlorine plus the carrying charges on the chlorine feed apparatus.

Age of Sewage and Temperature.—Whether we have simply local odors amenable to deodorants of the Phinotas type, or migrating odors requiring chlorine or activated sludge treatment, will depend largely upon the age of the sewage and its temperature. For time is a factor in the production of the troublesome hydrogen sulphide, the time necessary for its production in disturbing quantities being shortened as the temperature rises. Even though the sewage reaches the plant in a fairly fresh condition, hydrogen sulphide in odor producing volumes may develop in the settling tanks where these are larger than the minimum required for sedimentation.

Odors from Digesting Sludge.—Uncontrolled digestion of sludge with exposed surface is a prolific source of odor. However, with our present knowledge of optimum digestion conditions, there is little excuse for odors from this source. The floating covers used at the Plainfield plant effectively eliminate odors from this source by (a) preventing exposure to the atmosphere, (b) keeping all floating material submerged, in which case certain odoriferous compounds, otherwise formed, are not produced, (c) providing a perfectly safe means of collecting the gas generated, thus making it available for heating the digesting sludge to the optimum temperature.

Acknowledgment—The foregoing is a paper presented at the 19th annual meeting of the New Jersey Sewage Works Association.

Storage-Discharge Method of Sewer Design

Takes Advantage of the Full Value of the Storage Factor

By WM. R. MATHEWS
Engineer of Sewers, Bureau of Sewers, Chicago, Ill.

WHEN a system of sewers is designed by the rational formula the branches and upper part of the system have higher capabilities per acre than the lower parts, so that they flow but partly full during the rainfalls that fill the lower sections. If the lower sections be undersized the flow is restricted and the upper sections and branches fill. If there be sufficient storage in these parts of the system the entire system may prove adequate.

Sewers may be designed so that advantage may be taken of the full value of the storage factor by the application of what I will call the "storage-discharge" method, which may or may not be new. The computations necessary to apply the method are tedious, but by applying it to typical cases and comparing the results obtained with those by the use of the rational formula, sufficient data may be had for the modification of the rational equation, which may then be generally applied.

Basis of the Method.—What I have called the "storage-discharge" method of design is based on the proposition that during the time of concentration the total quantity of water entering a sewer system is equal to the quantity stored in it plus the quantity discharged at the mouth. Values may be given to this entering quantity, to the quantity stored, and the quantity discharged, and an equation may be written and solved to give the sizes of a sewer section by section, beginning at the upper end and working toward the outfall.

The first term of the equation is the quantity entering the sewer. This quantity is the product of the co-efficient C, of the intensity of rainfall I, of the area drained A, and of the time T'. The time T' is the time concentration less one half of the inlet time, it being assumed that, during the inlet time, the entering rate increases uniformly from zero to the full rate I. The entering quantity may be written $C\,I\,A\,T'$.

The second term of the equation is the storage. For the first section of the sewer it is the product of the length of the sewer and its cross-sectional area. For the second section of the sewer it is the product of the length and the cross-sectional area plus the storage in the first section. For the third and following sections it is obtained in the same manner.

The third term of the equation is the quantity discharged from the sewer. When the area drained is a rectangular one, with the sewer parallel with one edge, the quantity reaching the mouth of the sewer product $C\,I\,A$ and the discharge is therefore the product of the mean discharge and the time of concentration, or one half of $C\,I\,A\,T$. If the size of the sewer be reduced to take advantage of the storage the rate of discharge will increase uniformly as before until it reaches the full capacity of the sewer, and the sewer will then flow full for the remainder of the time of concentration.

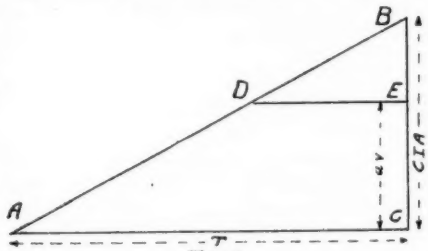


Fig. 1

The discharge of the sewer if reduced is shown by Fig. 1.

The base of the triangle ABC is the time of concentration T, the side BC is the product $C\,I\,A$, which is the rate of flow at the end of the time of concentration, and the area of the triangle, one half of $C\,I\,A\,T$, is the discharge at the mouth if the flow is not restricted. If the flow be restricted to take advantage of the storage the rate of discharge at the end of the time of concentration is represented by the line EC which is equal to av, the product of the cross-sectional area of the sewer and the velocity. The vertical ordinates of the line AD—DE represent the rates of flow during the time of concentration, and the area of the figure $ADEC$ the total discharge at the mouth. By similar triangles this area equals

$$T\left(av-\frac{a^2v^2}{2\,CIA}\right).$$

The equation for the design of a sewer by the storage-discharge method may now be written:

$$C\,I\,A\,T'=S+T\left(av-\frac{a^2v^2}{2\,CIA}\right)$$ in which

C = percentage of water reaching sewer.
I = intensity of rainfall.
A = area drained in acres.
or sewers.
S = storage, the cubical contents of sewer.
T = time of concentration in seconds.
a = cross-sectional area of sewer.
v = velocity.

Application of Methods.—I have applied this method to a district one-half mile wide containing 640 acres, with the sewer running lengthwise through the middle, with branches in two directions every 330 feet, each branch draining ten acres, using the following values:

$C = 25\%$.

$I=\frac{104}{t+17}$ (t = time of concentration in minutes).

T = time of concentration in seconds = length of sewer divided by velocity plus inlet time.

Inlet time = 5½ minutes.

V = velocity in sewer, 3 feet per second.

For the branches the discharge is $T\left(av-\frac{a^2v^2}{2\,CIA}\right)$, as given before. For the main sewer this was slightly modified, T being reduced to $T-\frac{330}{3}$, it being assumed that water entered the main only by way of the branches, so that there was no discharge at the down-stream end of each section of the main for the first 110 seconds.

The method was first applied to the terminal section of a branch sewer draining 2½ acres, then in turn to 5, 7½, and 10 acres; then to the first section of the main, draining 20 acres, and so on to the last section of the main draining 640 acres. The results have been compared with those obtained by the application of the rational formula and are shown on the curve Fig. 2. This shows curves for the values of Q for from 0 to 640 acres as computed by the rational formula and as computed by the "storage-discharge" method. A curve is also given which gives the ratio of the values obtained by the two methods.

Comparison with Rational Formula.—It will be noted that the size (cross-sectional area) of a sewer for 20 acres by the storage-discharge method is 83 per cent of the size by the rational formula and that for 640 acres the size is but about 63 per cent, the ratio of sizes decreasing with the increase of the acres. The curves shown do not extend beyond 640 acres, but some preliminary computations on a rectangular area one mile wide indicate that a sewer to drain about 2,000 acres designed by the storage-discharge method would be but about one-half the size of one designed by the rational formula.

The values of C which I have sug-

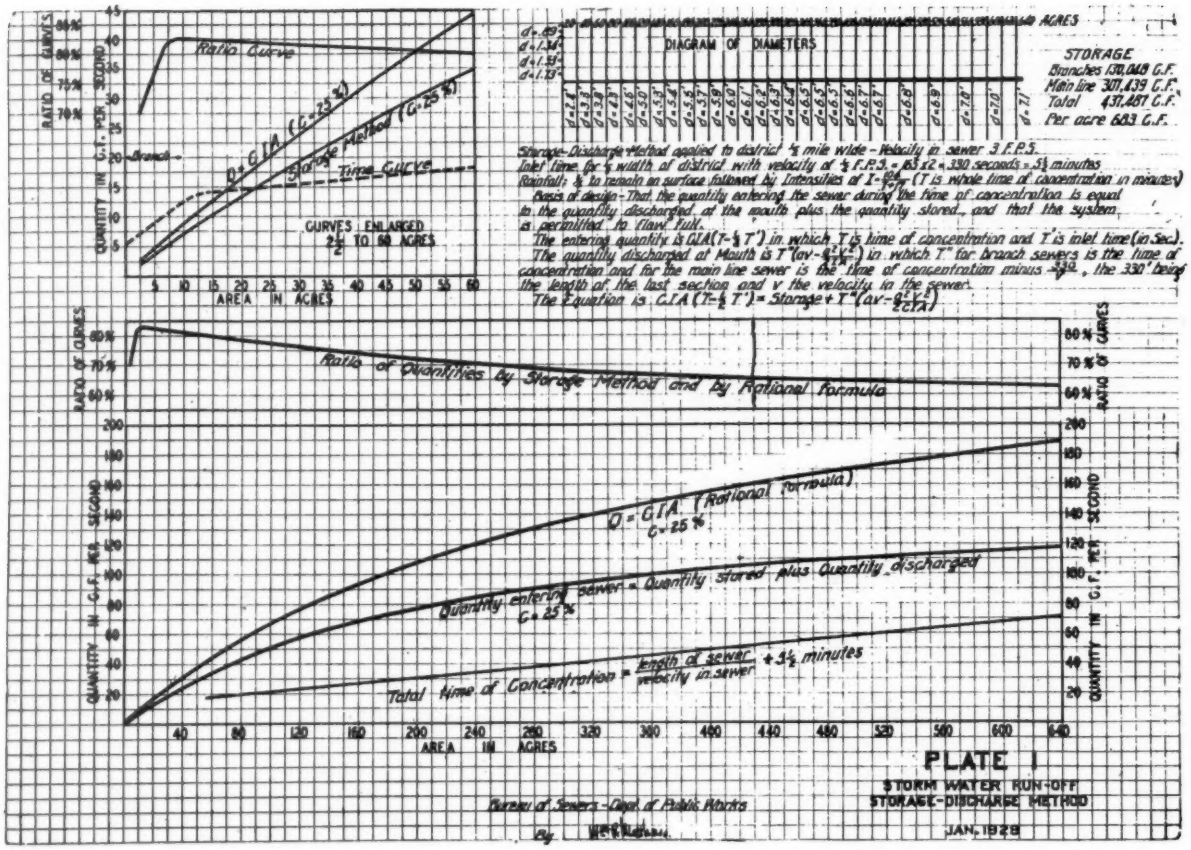

Ratio Curve
Storage Method (C=25%)
Rational Method (C=25%)
Time Curve
CURVES ENLARGED 2½ TO 60 ACRES
AREA IN ACRES
RATIO OF CURVES
QUANTITY IN C.F. PER SECOND
DIAGRAM OF DIAMETERS
STORAGE
Branches 130,048 C.F.
Main line 307,439 C.F.
Total 437,487 C.F.
Per acre 683 C.F.
Storage-Discharge Method applied to district ¼ mile wide - Velocity in sewer 3 F.P.S.
Inlet time for ¼ width of district with velocity of ½ F.P.S. = 165 x 2 = 330 seconds = 5½ minutes
Rainfall: ½" to remain on surface followed by Intensities of I = 60/T (T is whole time of concentration in minutes)
Basis of design - That the quantity entering the sewer during the time of concentration is equal to the quantity discharged at the mouth plus the quantity stored, and that the system is permitted to flow full.
The entering quantity is CIA(T - ½ T') in which T is time of concentration and T' is inlet time (in Sec.)
The quantity discharged at Mouth is T"(av - S/2CIA) in which T" for branch sewers is the time of concentration and for the main line sewer is the time of concentration minus 330, the 330 being the length of the last section and v the velocity in the sewer.
The Equation is C.I.A (T - ½ T') = Storage + T"(av - S/2CIA)
Ratio of Quantities by Storage Method and by Rational Formula
Q = CIA (Rational formula) C = 25%
Quantity entering sewer = Quantity stored plus Quantity discharged C = 25%
Total time of Concentration = Length of sewer / velocity in sewer + 5½ minutes
PLATE I
STORM WATER RUN-OFF
STORAGE-DISCHARGE METHOD
Bureau of Sewers - Dept. of Public Works
JAN. 1928

Fig. 2—Comparison of Calculations for Sewers by the Rational Formula and by the Storage-Discharge Method

gested for use in the rational formula of from 35 per cent to 45 per cent for "well built-up" areas and 60 per cent for areas approximately 100 per cent impervious are roughly equivalent to values of C in the storage-discharge formula of from 55 per cent to 65 per cent for "well built-up" areas and 85 per cent for areas approximately 100 per cent impervious. These latter values for C seem the more reasonable.

Acknowledgment.—The above is abstracted from a paper presented before the Western Society of Engineers.

Uses of Reclaimed Sewage at Grand Canyon

In an article on "Activated Sludge Practice in the United States" in our September issue, it was stated in the last paragraph on page 366, that "Chlorination of the effluent is carried out at Lodi, Pomona, Pasadena and Grand Canyon, in the first three instances to protect irrigated land from any germs of disease that might survive and at Grand Canyon for the drinking purposes in place of the restricted water supply."

This statement regarding the uses of effluent at the Grand Canyon was, of course, erroneous. As a matter of fact the reclaimed sewage at the Grand Canyon is used for industrial purposes only and every conceivable precaution has been taken to prevent any cross connection between the drinking water and reclaimed sewage water supply systems. A competent chemist is in charge of the treatment plant and frequent tests are made day and night to make sure that the reclaimed sewage is sterile at all times.

The following extract from a paper, "Sewage Treatment Plant at the Grand Canyon National Park," by H. B. Hommon, Sanitary Engineer, U. S. Public Health Service, the designer of the plant, brings out clearly the uses of the reclaimed sewage and the precautions that have been taken; it also gives some interesting information on the cost of operation:

Uses of Reclaimed Sewage.—At the present time the reclaimed sewage is used in stationary boilers for generating steam for heating purposes, and in the locomotives that haul passengers and freight trains on the branch line of the Santa Fe from Williams to the canyon; for cooling water for Diesel engines; for irrigating lawns around the hotel; and for flushing toilets in the public comfort stations in the El Tovar Hotel, Bright Angel Camp, railroad depot, and the Government automobile camp.

The force main from the treatment plant runs direct to the storage tank with only one branch taken off to supply cooling water for the Diesel engines. The entire distribution system from the storage tank is inclosed in vitrified pipes up to the outlets or fixtures where the reclaimed sewage is used. Beyond the vitrified pipe the uncovered distribution lines are painted red. The sewer pipe will prevent cross connections to fresh water lines. The pressure on the fresh water mains is greater than that on the reclaimed sewage lines. No valves, spigots, or any other openings are permitted on reclaimed sewage lines except where absolutely necessary. Accurate maps are kept up to date showing all the fresh water and reclaimed sewage pipe lines and no extensions or alterations of either piping system can be made without the approval of the superintendent of the park. With these limitations and precautions in distributing the reclaimed sewage, and the careful supervision given to the operation of the treatment plant, it is believed that it will be possible to use the reclaimed sewage indefinitely without any danger to the health of visitors to the park or of employees.

There has been no criticism by employees at the canyon who use the reclaimed sewage for generating steam or for any other purposes. The locomotive engineers vigorously opposed the use of "sewage" in passenger engines at first, but after a demonstration by an expert engineer they used the reclaimed sewage and found that it produced less scale than the fresh water obtained at the canyon.

All the reclaimed sewage is now being used for the purposes named above, and no others will be permitted, except possibly the washing of automobiles, under certain restrictions.

The treatment plant is operated under the supervision of a competent sanitary engineer who has two trained assistants.

Cost of Operation.—In considering the cost of operation, the fact should be kept in mind that the plant was designed and is operated to produce an effluent of the same degree of purity from a bacteriological standpoint as drinking water, and that every 1,000 gallons of reclaimed sewage that can be used in place of fresh water is worth $3.09. The cost data, therefore, should be considered in relation to water filtration rather than sewage disposal.

The average volume of sewage reclaimed daily during 1927 was 79,000 gal., and the itemized cost of treatment per 1,000 gal., was approximately as follows:

Electric current at 5 ct. per kilowatt:	
Operating blower	$0.20
Returning wash water	.003
Operating clarifier	.01
Lighting	.003
Labor for operating plant:	
2 operators and sanitary engineer	.177
Liquid chlorine, oil, grease, repairs to equipment, and extra labor	.009
Interest on investment (treatment plant only)	.086
Depreciation (treatment plant only)	.086
	.574

These costs would be reduced approximately one-half if the plant were operating at the capacity for which it was designed and if electric current were available at the commercial rate charged in cities; and the labor cost would decrease materially for plants treating large volumes of sewage.

Five Important Weather and Earthquake Cycles

Clay Varve and Tree Growth Records Employed With Electromagnetic Whirl Hypothesis

By HALBERT P. GILLETTE

A STUDY of annual tree-ring growth and of the annual clay laminae ("varves") deposited in ancient glacial lakes discloses five important weather cycles. For reasons given in "Municipal News and Water Works," and in "Engineering and Contracting," October, 1928, I have assigned these cycles to planets whose magnetic fields cause many sunspots when their north magnetic poles are pointed most directly at the sun. The magnetic fields of the sunspots, in turn, cause cyclonic storms on the earth, probably by producing a greater concentration of free electrons, or perhaps by releasing electrons from the atoms. The magnetic fields of the earth cause the free electrons in the air to rotate, thus producing both cyclonic storms and most of the general air currents that have hitherto been regarded as convection currents. Similarly electromagnetic whirls are caused in the molten interior of the earth.

The following are the lengths of five very important weather cycles, and dates of the last maxima:

Cycle Due to	Length of Cycle, Yr.	Last Maximum
Jupiter	11.214	1928.8
Uranus	81.15	1870.5
Neptune	161.4	1778.4
Planet A	322.4	1675.0
Planet E	3300	440 B. C.

In the article above referred to, I assigned the sunspot maximum of 1778 to Planet A (an unseen but clearly evident planet), but a more extended study of the radial growth of California giant redwoods and of clay varves has shown that Neptune caused that peak; and that the spot peak of 1675 was due to Planet A and not to Neptune.

Neptune's next sunspot peak will occur in 1939 at about the time that a Jupiter peak is due; and the next peak of Uranus will occur in 1951, also about the time of a Jupiter peak. In short, the conditions of 1778 and 1789 will soon be repeated, but with the added effect of Jupiter. Since the period of 1778-89 was one of unusual cold and precipitation, it is to be expected that the period of 1940-51 will be about the same. However, as will be shown in a later article, there is another factor that will tend somewhat to reduce the rainfall during 1940-51; but the 11-yr. period, 1951-1962, will be correspondingly wetter. Indeed this last-named period will probably be the coldest and wettest that has been experienced in North America since the 1778-89 period. This does not mean that all the years of these 11-yr. periods will be very wet, but only that the average wetness will be abnormal.

We have just passed through a relatively dry period of 22 years, and are now entering upon a relatively wet period of 33 years, because we are approaching sunspot peaks due to Neptune and Uranus, which have never failed to produce marked increases in the radial growth of the California and Arizona trees. The Arizona pines are particularly good recorders of rainfall, for they grow in relatively dry areas. Prof. Douglass has carefully measured their growth, and his charts and curves tell the rainfall story for every year back to 1395.

The clay varve measurements of Baron Gerard De Geer and of his one-time pupil, Prof. Ernst Antev, constitute an invaluable record of precipitation running back 18,000 years. The California redwoods give rainfall records for about 3,000 years. These varves and tree-ring records have been the main sources of information by which I have checked my theory as to the weather cycles caused by the planets named above. However, without a theory to guide me I doubt whether I should have found these cycles at all, except, of course, the well known cycle of 11.2 years. The other four cycles have far more important weather effects than that of Jupiter, but coming less frequently they have not been recognized as being regular cycles of the lengths above given.

The 3,000-year cycle is one of the most interesting, for it produces profound effects. The very cold and wet period that prevailed for a long time around 440 B. C. was followed by an exceedingly arid period for many years, centering about 1200 A. D., which was finally relieved by a wet cycle caused by Planet A, culminating in the very wet and stormy years of the 14th century, when planets A, Uranus and Neptune produced very severe weather.

There are three names that I venture to predict will ultimately stand very high in the history of meteorology, yet not one of the three is the name of a professional meterologist. I refer to Professors De Geer, Douglass and Huntington, named in the order of the dates of their first publications relating to weather cycles. Professor De Geer, the great Swedish geologist, began his study of annual clay varves more than 50 years ago, and soon found a periodic variation of about 11 years. Professor Douglass, an astronomer, began his study of tree-rings in 1904 and also soon found the 11-yr. cycle, together with an intermediate cycle of about 5 or 6 years. Professor Huntington, a geographer, at about the same time began publishing the results of his studies showing historic cycles of climatic changes. Then he followed this up with his measurements indicating a grand cycle in the growth of California redwoods, culminating about the fifth century before Christ, but he did not deduce the length of that cycle. He also found the 11-yr. cycle in the growth of these giant trees. Professor Douglass then made a more detailed study of California redwood growth, confirming Professor Huntington's general conclusions.

In spite of the clear evidence given by this remarkable pioneer work of De Geer, Douglass and Huntington, meteorologists have practically ignored it, and have not followed it up with any independent investigations of consequence. Hydraulic engineers, who are appliers of science rather than researchers, have not used the clay-varve and tree-ring data, because there was an evident complexity that made the data of little practical utility.

About three years ago, I began a determined attack upon this problem, with results that are already very satisfactory. I have found the cause of sunspots, and I have found a sunspot cycle due to every one of the eight visible planets, and to several planets as yet unseen but knowable by their effects on tree-growth; clay-varve thickness and the periodicity of geological epochs, periods and eras. (See the article above mentioned.) If skepticism arises as to any such knowledge about unseen planets, it should be remembered that no one has yet seen a molecule, to say nothing of an atom or an electron. Yet we confidently act upon atomic and electric theories—based upon the existence of those invisible units of matter. It will not be long, I think, before weather forecasters will take into consideration the effects of invisible planets, notably Planet A, the planet whose existence Lowell and Flammarion have independently predicted from astronomical considerations. I am now confident that it caused the sunspot maximum of 1675. There is a marked bulge about 1675 in the curve of tree growth of Arizona pines, and a series of such bulges prior thereto, about 322 years apart, on the curve of California redwood growth that I have plotted from the tables given by Professor Douglass. This latter curve extends from 1220 B. C. to 1914 A. D., giving the thickness of wood added each year.

In this connection it may be well to speak of the significance of the tree-growth maxima that occur about midway between the Jupiter sunspot peaks, that is, at sunspot valleys or minima. Douglass is the first to have mentioned this phenomenon; but he offered no explanation of it. At first it seemed to me likely that it is due to the periodic shifting of storm tracks, according to Kulmer's law; but more mature reflection showed that this could not explain the phenomenon.

According to the electron-whirl theory of sunspot and weather cycles, free electrons migrate on the earth under the influence of the magnetic fields of the sun, sunspots and planets. This migration changes the density of the free electrons in the atmosphere and in the earth, and results in changes in the intensity of the 12 permanent cyclonic whirls and of the numberless migrating cyclonic whirls. While sunspots, because of their magnetic fields, are important factors in causing such migrations of electrons, the magnetic fields of certain planets are much more important. Thus, when either one of Jupiter's magnetic poles is most inclined toward the earth, many cyclonic storms are generated on the earth. The same holds true of Uranus, Neptune and Planet A.

Incidentally this migration of electrons explains the existence of the flow of electrons from the earth to the air above it; for electrons migrate from the Heaviside layer (75 miles above the earth) downward toward the poles and thence through the earth toward the equator. In short, streams of rotating belts of electrons are maintained by magnetic pressure. The same sort of phenomenon occurs on the sun, and accounts for sunspots and for their periodicities.

Accordingly I adopted the hypothesis that although Jupiter's magnetic field produces few sunspots when its north magnetic pole points sunward, it does produce a concentration of free electrons in the earth's lower air and molten matter, so that both air-whirls and molten-whirls of greater frequency, intensity and size result. In short, Jupiter acts directly upon the earth when its north magnetic pole points earthward. Probably it also acts directly on the earth when its south magnetic pole points earthward, but this effect is so commingled with the effect of the sunspots that are then generated in great numbers as to make it difficult to determine the direct action of Jupiter.

No sooner had I reached this conclusion than I saw that there is a weather cycle of about 5.6 years (½ of 11.2) which intermediate rainy periods from a Jupiter peak is due to its north pole. These cycles are not precise as to time, there being a small swing on each side of the mean, because the earth travels in an orbit, cutting across the magnetic field of Jupiter twice each year. Jupiter is moving orbitally eastward and its magnetic poles are slowly rotating westward, which introduces some complexity, but a complexity that is rendered relatively simple when studied in the light of the facts just given.

In a chart of annual earthquake intensity, given by Edward Lynch in his "Solar Physics and Earthquakes," I find clear evidence not only of the 11.21-yr. cycle of Jupiter, but of the half period above mentioned. Huntington has commented upon the general tendency of rainfall maxima and earthquake maxima to concur, and this adds another bit of evidence in support of that theory. Huntington attributes such concurrence to the great changes in air pressure on the earth during stormy periods, whereas I attribute it to the molten-whirls in the earth that are electromagnetically generated by the same causes that generate the air-whirls.

The Encyclopedia Americana, under Disasters, cites 28 disastrous earthquakes and 38 great plagues and pestilences that have afflicted the world since the birth of Christ. I have listed all of these in the footnotes of Table I. Study discloses that great earthquakes have frequently occurred near the time of a Uranus maximum, and not infrequently near the time of a Uranus minimum magnetic effect. The same holds true of plagues. Since the latter are often caused by bacteria that are the hosts of mosquitoes, and since mosquitoes are more prevalent during rainy periods, there is a reason for the cycles of certain plagues. Perhaps all bacteria thrive best during rainy periods.

Of the 28 disastrous quakes, 13 occurred within 9 years of a Uranus maximum (Table I). Since the Uranus cycle is about 81 years, the probability that this would occur by chance is 1 in 3,594; for $2\times9=18$ years and $81\div18=4.5$; whence the probability of a single occurrence is 1 in 4.5. But there are 13 occurrences out of 28, whence by applying formula 23 given in "Probability and Its Engineering Uses," by T. C. Fry, we get a probability of 1 in 3,594.

By way of explanation, there is a probability that this event could occur 28 times out of 28 possibilities. The measure of this probability would be $\frac{1}{4.5^{28}} = \frac{1}{1{,}995{,}100{,}000{,}000{,}000{,}000}$, which is quite small. That is, this fraction measures the probability that the event would occur every time it had the chance, considering the occurrence as fortuitous rather than as demanded by physical law. If there were 28 opportunities for the quakes to occur, the chance of 28 occurrences would be measured by the fraction above.

According to hypothesis there were 28 chances for quakes to occur. According to fact there were 13 occurrences. The hypothesis states that conditions were such as to expect quakes.

If 28 quakes are expected to occur according to physical theory, and 28 occurrences are recorded, then we are likely to assume that $\frac{28}{28} = \frac{1}{1}$, and hence it is a certainly that these conditions absolutely cause quakes. But this reasoning is not quite true, because there is the possibility, as shown by the fraction, that the quakes could occur accidentally coincident with the theoretical or hypothetical favorable conditions.

So far as physical law and probability are concerned there is a difference in status if a quake occurs accidentally or if it is expected. Conditions could be favorable, according to physical theory, for the occurrence of a quake, yet the quake could occur accidentally while those conditions prevailed. The fraction, $\frac{1}{3594}$, measures the probability of getting 13 occurrences accidentally.

It is noteworthy that Jupiter assisted Uranus in producing many of the disastrous quakes. A Jupiter maximum occurred within a year of 10 of the 28 quakes. Hence $11.2\div2=5.6$; whence the probability of a single occurrence is 1 in 5.6; and the probability of 10 out of 28 is 1 in 80.

The two probability ratios thus deduced are much smaller than the actual probability ratio, for I have taken the extreme departure of an earthquake from the peak effect of each planet; and have made no allowance for the fact that many quakes occur near the time when a planet's south magnetic pole points most nearly sunward, which is at a sunspot minimum.

Huntington and Vischer, in "Climatic Changes," have conclusively demonstrated that earthquakes are most numerous at times of sunspot maxima; but this does not conflict with my inference that they are also abnormally numerous at times of sunspot minima.

The San Francisco quake of 1906 came a few days after an unusual eruption of Vesuvius and almost at the time of a Jupiter maximum effect, and 4 years before a Uranus minimum effect. San Francisco suffered from a severe quake in 1868, two years before a Uranus maximum, and near the time of a Jupiter minimum. A much greater shock occurred in 1872, at the time of a Jupiter maximum, in Owens River valley, about 200 miles east of San Francisco. None of the California quakes have been severe. The quake of 1906 did little damage in San Francisco. The damage was caused by the fire that followed it, as a result of the breaking of water mains. The quakes have their origin along certain well defined faults—where slippage occurs—as a result of the ascending molten-

Table I—Dates of Greatest Sunsport Effects Assigned to Four Plants

	(11.21 yr.) Jupiter A. D.	(81.15 yr.) Uranus A. D.	(161.4 yr.) Neptune A. D.	(322.4 yr.) Planet A A. D.
	0.7	4.9	3.0	.....
(a)	11.9	.....	.....	.....
	23.1	.....	.....	.....
	34.3	.....	.....	.....
	45.5	.....	.....	.....
	56.7	.....	.....	.....
	67.9	.....	.....	63.0
(b)	79.1	.....	.....	.....
	90.4	86.0	.....	.....
	101.6	.....	.....	.....
(c)	112.8	.....	.....	.....
	124.0	.....	.....	.....
	135.2	.....	.....	.....
	146.4	.....	.....	.....
(d)	157.6	.....	.....	.....
	168.8	167.2	164.4	.....
	180.0	.....	.....	.....
	191.2	.....	.....	.....
	202.5	.....	.....	.....
	213 7	.....	.....	.....
	224.9	.....	.....	.....
	236.1	.....	.....	.....
(e)	247.3	248.4	.....	.....
	258.5	.....	.....	.....
	269.7	.....	.....	.....
	280.9	.....	.....	.....
	292.1	.....	.....	.....
	303.3	.....	.....	.....
	314.6	.....	.....	.....
	325.8	329.5	325.8	.....
	337.0	.....	.....	.....
	348.1	.....	.....	.....
	359.4	.....	.....	.....
	370.6	.....	.....	.....
	381.8	.....	.....	385.4
	393.0	.....	.....	.....
	404.2	.....	.....	.....
	415.4	410.7	.....	.....
(f)	426.7	.....	.....	.....
	437.9	.....	.....	.....
	449.1	.....	.....	.....
	460.3	.....	.....	.....
	471.5	.....	.....	.....
	482.7	.....	487.2	.....
	493.9	491.8	.....	.....
	505.1	.....	.....	.....
	516.3	.....	.....	.....
	527.6	.....	.....	.....
	538.8	.....	.....	.....
	550.0	.....	.....	.....
(g)	561.2	.....	.....	.....
	572.4	573.0	.....	.....
	583.6	.....	.....	.....
	594.8	.....	.....	.....
	606.0	.....	.....	.....
	617.2	.....	.....	.....
	628.4	.....	.....	.....
	639.6	.....	.....	.....
	650.9	654.1	648.6	.....
	662.1	.....	.....	.....
	673.3	.....	.....	.....
	684.5	.....	.....	.....
	695.7	.....	.....	.....
	706.9	.....	.....	707.8
	718.1	.....	.....	.....
	729.3	.....	.....	.....
(h)	740.5	735.3	.....	.....
	751.7	.....	.....	.....
	763.0	.....	.....	.....
	774.2	.....	.....	.....
	785.4	.....	.....	.....
	796.6	.....	.....	.....
	807.8	.....	810.0	.....
	819.0	816.4	.....	.....
	830.2	.....	.....	.....
	841.4	.....	.....	.....
	852.6	.....	.....	.....
	863.8	.....	.....	.....
	875.1	.....	.....	.....
	886.3	.....	.....	.....
	897.5	897.6	.....	.....
	908.7	.....	.....	.....
	919.9	.....	.....	.....
(i)	931.1	.....	.....	.....
	942.3	.....	.....	.....
(j)	953.5	.....	.....	.....
	964.7	.....	.....	.....
	975.9	978.7	971.4	.....
	987.2	.....	.....	.....
	998.4	.....	.....	.....
	1009.6	.....	.....	.....
	1020.8	.....	.....	.....
	1032.0	.....	.....	1030.2
	1043.2	.....	.....	.....
	1054.4	1059.9	.....	.....
	1065.6	.....	.....	.....
	1076.8	.....	.....	.....
	1088.0	.....	.....	.....
	1099.3	.....	.....	.....
	1110.5	.....	.....	.....
	1121.7	.....	.....	.....
	1132.9	.....	1132.8	.....
	1144.1	1141.0	.....	.....
	1155.3	.....	.....	.....
	1166.5	.....	.....	.....
(k)	1177.7	.....	.....	.....
	1188.9	.....	.....	.....
	1200.1	.....	.....	.....
	1211.4	.....	.....	.....
	1222.6	1222.2	.....	.....
	1233.8	.....	.....	.....
	1245.0	.....	.....	.....
	1256.2	.....	.....	.....
(l)	1267.4	.....	.....	.....
	1278.6	.....	.....	.....
	1289.8	.....	1294.2	.....
	1301.0	1303.3	.....	.....
(m)	1312.2	.....	.....	.....
	1323.5	.....	.....	.....
	1334.7	.....	.....	.....
(n)	1345.9	.....	.....	.....
	1357.1	.....	.....	1352.6
	1368.3	.....	.....	.....
(o)	1379.5	1384.5	.....	.....
	1390.7	.....	.....	.....
	1401.9	.....	.....	.....
	1413.1	.....	.....	.....
	1424.3	.....	.....	.....
	1435.6	.....	.....	.....
	1446.8	.....	.....	.....
(p)	1458.0	.....	1455.6	.....
	1469.2	1465.6	.....	.....
(q)	1480 4	.....	.....	.....
	1491.6	.....	.....	.....
	1502.8	.....	.....	.....
	1514.0	.....	.....	.....
	1525.2	.....	.....	.....
(r)	1536.4	.....	.....	.....
	1547.7	1546.8	.....	.....
	1558.9	.....	.....	.....
	1570.1	.....	.....	.....
	1581.3	.....	.....	.....
	1592.5	.....	.....	.....
(s)	1603 7	.....	.....	.....
	1614.9	.....	1617.0	.....
(t)	1626.1	1627.9	.....	.....
	1637.3	.....	.....	.....
	1648.5	.....	.....	.....
	1659.8	.....	.....	.....
(u)	1671.0	.....	.....	1675.0
	1682 2	.....	.....	.....
(v)	1693.4	.....	.....	.....
	1704.6	1708.1	.....	.....
	1715.8	.....	.....	.....
(w)	1727.0	.....	.....	.....
	1738.2	.....	.....	.....
(y)	1749.4	.....	.....	.....
	1760.6	.....	.....	.....
	1771.9	.....	1778.4	.....
(z)	1783.1	1789.3	.....	.....
	1794.2	.....	.....	.....
	1805.5	.....	.....	.....
	1816.7	.....	.....	.....
(aa)	1827.9	.....	.....	.....
	1839.1	.....	.....	.....
	1850.3	.....	.....	.....
	1861.5	.....	.....	.....
(bb)	1872.8	1870.5	.....	.....
(cc)	1884.0	.....	.....	.....
	1895 2	.....	.....	.....
(dd)	1906.4	.....	.....	.....
	1917.6	.....	.....	.....
	1928.8	.....	.....	.....
	1940.0	.....	1939.8	.....
	1951.2	1951.7	.....	.....
	1962.4	.....	.....	.....
	.....	.....	.....	1997.4

(a) Earthquake destroyed Ephesus, 17 A. D.
(b) Pompeii destroyed by earthquake and eruption of Vesuvius in 79 A. D. Great plague in Rome in 80 A. D.
(c) Earthquake destroyed Antioch, 115 A. D.
(d) Earthquakes destroyed 150 towns in Asia and Macedonia in 157 A. D. Rome stricken with plague, 167 A. D.
(e) Rome plague stricken again, 250 A. D.
(f) Great Britain plague stricken, 430 A. D.
(g) Earthquake killed thousands in Constantinople, 557 A. .D
(h) Earthquakes caused terrible loss of life in Syria, Palestine and Asia, 742 A. D. Plague killed 200,000 in Constantinople, 746-9 A. D.
(i) Earthquake destroyed Constantinople, 936 A. D.
(j) Plague killed 40,000 in Scotland, 954 A. D.
(k) Severe plague in Ireland, 1172.
(l) Earthquake killed 60,000 in Cilicia, 1268.
(m) Greatest English earthquake, 1318.
(n) Plague ("black death") swept Europe, 1340.
(o) Plague ("frightful mortality") in Europe, 1362-79; and "the fourth pestilence" in Ireland, 1383.
(p) Earthquake killed 40,000 in Naples, 1456.
(q) Plague ("sweating sickness"), 1485.
(r) Earthquake killed 30,000 in Lisbon, 1531.
(s) Plague killed 30,000 in London, 1603-4.
(t) Earthquake killed 70,000 in Naples, 1626; plague killed 35,000 in London, 1625; and 60,000 in Lyons, 1632.
(u) Earthquake killed 80,000 in Shamazi, 1667; plague killed 400,000 in Naples, 1656; and 10,000 in London in 1664-5.
(v) Earthquake killed 100,000 and destroyed 354 towns in Sicily, 1693; plague killed 60,000 in Marseilles, 1720.
(w) Earthquake killed 100,000 in China, 1731.
(y) Earthquake killed 18,000 in Lima and Callao in 1745; 50,000 in Lisbon, 1755; "awful plague" in Syria, 1760; "Putrid fever" in France, 1773.
(z) Earthquake killed 40,000 in Cuzco and Quito, 1797. Plague killed 20,000 in Smyrna, 1784; 250,000 at Suez in 1799.
(aa) Earthquake killed 20,000 in Aleppo, 1822; "terrible plague" in Asia Minor, Palestine and Greece, 1814; in Calcutta, Bombay, Siam (Asiatic cholera), 1817-18; cholera in Tunis, 1819-22; cholera in Europe and America, 1831-2.
(bb) Earthquake killed 10,000 and destroyed many towns in Kingdom of Naples, 1857; killed 25,000 in Peru and Ecquador, 1868 (San Francisco suffered severely, 1869); killed many in Guatemala, 1874 (Great shock in Owen's River Valley, Calif., 1872). Cholera killed many in Europe, 1865.
(cc) Earthquake devastated Java, 1883 (Krakatoa exploded, 1883); Charlestown quake, 1886; great shocks in southern Europe, 1887. Yellow fever killed many in America, 1878; cholera raged in Europe, 1884-5, and again in 1892.
(dd) Earthquake at San Francisco, April 18, 1906; quake in southern Italy killed 150,000 in 1908.

Table II—Dates of 28 Sunspots Maxima, Jupiter's Max. Magnetic Solar Effect, Auroral Max., Etc.

Jupiter Cycle (11.21 yr.)	Sunspot Max. of Smoothed Curve	Auroral Max.	Big Wine Harvests	Big Hail-storms
1614	1615	1620	1616	1617
1626	1626 (U)	1629	1624	1630
1637	1639	1640	1637	1640
1648	1649	1647	1648	1649
1659	1660	1661	1657	.....
1670	1675 (A)	1677	1678	1676
1682	1685	1683	1686	.....
1693	1698	1690	.....	1688
1704	1705 (U)	1707	1704	1704
1715	1718	1719	1718	1720
1727	1727	1730	1727	1731
1738	1738	1739	1737	1740
1749	1750	1748	1748	.....
1760	1761	1760	1762	1762
1771	1769	1772	1775	1770
1783	1778 (N)	1778	1782	1780
1794	1788 (U)	1788	1790	1788
1805	1804	1804	1804	1804
1816	1816	1818	1819	1819
1827	1829	1829	1829	1828
1839	1837	1840	1837	1839
1850	1848	1850	1848	1848
1861	1860	1860	1860	1859
1872	1870 (U)	1870	1870	1869
1884	1883	1883	1883	1883
1895	1894			
1906	1906			
1917	1917			

Note: A=Planet A; N=Neptune; U=Uranus. The last three columns are given by Fritz.

whirls which behave like ascending cyclonic air-whirls.

Table II gives the dates that I have assigned to the maximum sunspot effect due to Jupiter, and in the next column are the dates that Wolf assigned to sunspot maxima; then follow dates of maxima assigned by Prof. H. Fritz (see "Monthly Weather Review," October, 1928, for a translation of his remarkable article published in 1893) to aurora, wine harvests and hail-storms. His dates of auroral maxima do not always agree exactly with those in the Encyclopedia Britannica, under Aurora, but the differences are immaterial for present purposes. Note the remarkable concurrence of the dates of maxima in the five columns of Table II, bearing in mind that 6 of the 28 sunspot peaks are due to the planets Uranus, Neptune and A, as per Table I. The 22 remaining sunspot maxima find agreement, within a year, in 15 instances.

Since any single instance of such agreement would occur by accident only once in 5.6 times, the occurrence of 15 out of 22 such agreements would be accidental only once in 3,881,455 times, according to the probability formula above cited. This alone would serve to establish the substantial correctness of the Jupiter spot cycle of 11.214 years, but I have established with vastly greater conclusiveness by tracing it back more than 3,000 years in the California redwood rings and 16,000 years back in the clay varves. By aid of the Jupiter, Uranus, Neptune and Planet A cycles, I find that the zero year on Professor DeGeer's chart is 6,764 B. C., and the year 3,000 on Professor Antev's varve chart is 12,449 B. C.; and the zero year on Reed's varve chart is 12,651 B. C. Professor De Geer had previously correlated Reed's American varves and some of Antev's American and Canadian varves with his (De Geer's) Swedish varves, and had expressed the hope that his varve dates would eventually be correlated with the dates of the rings of the California redwoods. He had estimated that his zero year was 6,800 B. C., and I find his estimate to be only 36 years away from the truth.

Professor De Geer has accomplished one of the most remarkable feats in the history of geology, for he has precisely correlated events of the last glacial epoch in Europe, America, Iceland, Argentine and India, by means of clay varves. He has shown fully 80 per cent agreement as to annual changes in thickness of varves. Since the chance is 1 in 2 that two sets of varves will agree by accident, it follows that if 15 successive agreements occur (and this happens very frequently) there is only 1 chance in 2 raised to the 15th power, or 1 in about 36,000, that such a concurrence is accidental. Occasionally 30 or more successive concurrences are to be seen on De Geer's charts, which could not occur by accident once in a billion times. The evidence is thus seen to be overwhelming that De Geer has effected a coordination of the clay varves in five areas that are widely separated; and this, I maintain, is one of the most remarkable achievements in the history of geology. I believe that it is also destined to have a profound effect, not only on meteorology, but on astronomy. For more than half a century this remarkable man has been making and gathering clay-varve measurements; but not until four years ago did he succeed in thus tying together the ice-age chronology of Europe and America. Even yet his great achievement is known by comparatively few scientists, and scarcely at all by the public. Such is too often the slow coming of merited fame.

Automatic Chlorination

Results of a Year's Experience at Concord, N. H.

By PERCY SANDERS
Superintendent of Water Works, Concord, N. H.

ON account of the source of supply being a surface supply and therefore liable to to possible contamination, the water board was advised by Metcalf & Eddy, consulting engineers, the New Hampshire State Board of Health concurring, to chlorinate the water. It was voted by our water board to carry out these recommendations and Metcalf & Eddy were authorized to submit a plan for the installation of a chlorinating plant. Owing to the good record which the water has shown in the way of sanitary and chemical analyses during the 57 years that it has been in use, it was decided that a comparatively minimum in amount of chlorine should be used.

The flow varied from 500,000 gal. to 6,250,000 gal. per day. An automatic type machine was recommended and installed in the fall of 1928 and has now been in operation practically a year.

The machine was furnished by Wallace & Tiernan Co., Inc., and is their Type ASVM automatic control vacuum feed chlorinator with an Ortho-Tolodin testing outfit.

Before the type of machine was decided upon, tests were made of the range of the differential heads on the Venturi and it was found that they varied from .4 ft. to 5.82 ft., or a ratio of 1 to 14.5.

The equipment is placed in the gate house, a small room having been built for it, and the water is chlorinated after passing through the screens.

Rate of Application.—Four meter tubes were furnished which permit the chlorine to be applied at the rate of 30 lb. per 24 hours; 24 lb. per 24 hours; 17 lb. per 24 hours; and 15 lb. per 24 hours, respectively. When we first started the machine we used the 17-lb. tube, which gave a dose of 2.8 lb. per million gallons; later we changed to the 15-lb. tube, which gives a dose of 2.5 lb. per million gallons, or .33 part per million.

The pressure on the line used to carry the chlorine into the water is 33 lb. and the amount of water used to operate the machine in 24 hours is 6,000 gal., or approximately 2,200 gal. for each million gallons chlorinated.

The Ortho-Tolodin test is made a short distance below the Venturi meter at intervals to ascertain if any residual or free chlorine is present, and while we always get a residual at this location, in making the same test at the pumping station we get none at all, showing that all chlorine has been absorbed.

How Chlorinator is Operated.—The chlorinator is operated by the throat and inlet pressures from the Venturi meter located 66 ft. from the machine, which differential pressure is transmitted 22 ft. to a differential convertor. The convertor changes the differential pressure to a vacuum which operates the chlorinator, the convertor being 44 ft. from the chlorinator and 22 ft. below it in elevation.

The operation of the machine was put under the charge of one of our permanent men who was carefully drilled in the care of it by Mr. Hart of Wallace & Tiernan Co., Inc.

The machine is visited four days a week to weigh the chlorine and check it up.

In the winter months we have a little difficulty in keeping the chlorine, chlorine tank and the room itself in an even temperature. Heat is supplied by an ordinary oil heater with reservoir connected by a small pipe to a 10-gal. tank, the flow line of which is at same level as the burner.

The vacuum line leading from the differential convertor to the machine has to be closely watched and drained as condensation will collect and prevent chlorination.

A small bottle of ammonia is kept to detect leaks in the equipment and a gas mask is kept just inside the main door of the gate house for emergency use in case of bad leaks.

We purchase the liquid chlorine from Brown & Co. of Berlin, N. H., who manufacture and use great quantities of it in connection with their bleaching processes.

The machine was in operation for several months before the fact was made public and during that time no complaints were received at the office of any unusual taste or odor in the water.

However afterwards, the case was different for a while; discoloration was noted on glassware, one or two persons had boils which they thought could be attributed to the chlorine and many people thought that the water had tasted queer for some time but hadn't known what the trouble was; we even had communication by mail assuring us that some had detected the change in the water several weeks before.

Everything is quiet now; we are chlorinating regularly and continually and no one notices the difference in the ordinary course of events; occasionally some solitary consumer will return from a vacation and inquire if the water from pipes unused for a month or two tastes and smells queer from the chlorine, but these complaints seem to be the only reminder of the change. There has been no marked improvement in the health of our citizens, but we rest secure that we are doing our best to give our community a clear and sterile water.

Acknowledgment.—The above is an abstract of a paper presented Sept. 18 at 48th annual convention of the New England Water Works Association.

Court Decisions on Sanitary Matters

Recent Rulings of Supreme Courts of Various States

Discharge of Sewage by Borough in Manner to Overflow Land Enjoined.—(Pennsylvania Supreme Court; Freedman et al. v. Borough of West Hazleton, 146 A. 564; decided May 13, 1929.) The borough of West Hazleton discharged sewage, at a certain place in the borough, into an open ditch. This ditch extended over plaintiffs' land to a creek. The polluted fluid spread, at various points along the ditch, over the land of plaintiffs and caused the emission of offensive odors which created inconvenience and unhealthful conditions to families living along the ditch within the borough. In an injunction suit brought by the plaintiffs, whose land consisted of plotted building lots which were suitable and available for residential purposes, the trial court found the above facts. It was also proved that the sewer system, at the point where the sewage entered the ditch, was wholly inadequate and insufficient to prevent the discharge of the polluted waters upon the plaintiffs' property. The trial court concluded that there was a public and continuing nuisance and granted the relief prayed for by the plaintiffs. On appeal by the defendant borough, the supreme court affirmed the lower court's decree, saying that "The facts in this case and the law applicable to them fully support the findings and final decree of the court below."

Regarding the claim, put forth by the borough, that it had a prescriptive right to the use of the ditch over plaintiffs' land, it was held by the supreme court that such claim had no application. The court stated that, although the ditch had been openly used for that purpose since 1902, that fact constituted no defense to a proceeding by an individual for the removal of an unlawful nuisance which developed in later years from such use, and that "the right to maintain a public nuisance can not be acquired by prescription."—Public Health Reports, Aug. 16, 1929.

Provisions of Ordinance Concerning Removal of Garbage Upheld.—(Oregon Supreme Court; Spencer et al. v. City of Medford et al., 276 P. 1114; decided April 23, 1929.) The city of Medford, by ordinance, declared it to be unlawful and punishable by fine or imprisonment for any person, firm, or corporation, other than a certain named corporation, to collect, gather, or haul over the streets of the city any garbage. The plaintiffs, in a suit to restrain the enforcement of the said ordinance, alleged that they were under contract with certain hotels, cafes, and restaurants to purchase and remove the garbage of such establishments; that they removed such garbage in a sanitary manner to places outside the city; and that such garbage was there used by them as feed for hogs. The plaintiffs claimed that the ordinance created a monopoly and was class legislation. The conclusion reached by the supreme court was that the city had authority to pass the ordinance in question and that the provisions thereof relative to garbage were reasonable.—Public Health Reports, Aug. 2, 1929.

City's Sewage Disposal Plant Not Enjoined.—(Texas Court of Civil Appeals; City of Wylie et al. v. Stone, 16 S. W. (2d) 862; decided April 10, 1929.) An action was brought against the city of Wylie and its mayor and aldermen to enjoin the operation of the city's sewage-disposal plant and to abate same, on the ground that its operation was a public and private nuisance. The jury's findings justified the conclusion that the plant as operated was a nuisance. The jury also found that the plant could have been located and operated in a practical manner on another site that would not have caused injuries to others similar to those inflicted on plaintiff; that plaintiff's land was depreciated in market value $5,000; and that the city would suffer $8,000 loss if an injunction were granted. The trial court abated the plant as a nuisance, enjoining the defendants from operating same at the location complained of. On appeal the judgment of the trial court was reversed by the court of civil appeals.

One of defendants' contentions was that, the legislature having authorized the governing authorities of the city to locate and establish the sewage plant, the nuisance, if any resulted from its operation, was legalized. The appellate court, however, held that the nuisance complained of did not belong to the category of those legalized, but, in a proper case, could be enjoined.

Another contention of defendants was that the trial court had erred in not directing a verdict in their favor because the evidence failed to show the existence of a nuisance, but this was overruled, for the reason that the jury's findings justified the conclusion that the disposal plant as operated was a nuisance.

In passing on another point raised by the defendants the court of appeals decided that "the jury should have been required to find in substance whether or not, under all the facts and circumstances, there existed a reasonable necessity for the location of the disposal plant at the point selected."

It was also contended that the plaintiff was not entitled to injunction relief as a matter of right, but should have been relegated to his action for damages. In discussing this phase of the matter the court said:

> It does not follow that every nuisance will be enjoined; courts will consider the equities pro and con. Ordinarily, where there exists an adequate remedy at law, a nuisance will not be suppressed by injunction; especially is this true in cases of the nature of the one under consideration, where the interest and convenience of an entire community is involved as against a private or personal inconvenience or loss that may be measured in dollars and cents.* * *
>
> One of the major functions of a municipal government is to insure proper sanitation and preserve public health; to this end the law, by express provisions of the statute and by many implications therefrom, has committed to governing authorities of cities, such as Wylie, the duty of establishing and operating sewer systems. They are authorized to purchase necessary lands, either within or without the city limits (art. 1108, R. S. 1925), and, when necessary, may acquire lands by condemnation proceedings (art. 1109b, R. S. 1925). Therefore, wherever these authorities act the presumption will be indulged, until overcome by a preponderance of evidence, that they acted in good faith, with due regard to the rights and interest of all concerned, and found a reasonable necessity for making the particular location. Courts are not authorized to substitute theirs for the judgment of authorities whom the law has clothed with exclusive authority to act, and their discretion, when exercised, should not be disturbed except in a clear case of abuse, which we do not find committed in this case.—Public Health Reports, July 12, 1929.

Garbage-Removal Ordinance Upheld and Refusal of Garbage-Removal Permit Sustained.—(Ohio Supreme Court; State ex rel. Moock v. City of Cincinnati et al.; Moock v. Same, 166 N. E. 583; decided May 1, 1929.) An ordinance of the city of Cincinnati provided as follows:

> That no person shall remove or carry in or through any of the streets, squares, courts, lanes, avenues, places, or alleys * * * any house dirt or house offal, animal or vegetable, or any refuse substance, from any of the dwelling houses or other places of the city. * * * unless the owner of the same shall have procured a permit so to do * * * prescribing the terms and conditions as may be deemed essential to the health and interests of the city. Provided, however, the provisions hereof shall not apply to any contractor with the city in relation to garbage.

The city contracted with a company for the collection and disposal of the garbage of the city for a 5-year period. The relator, who had contracts with various hotels, restaurants, and eating places to remove their garbage, was refused a permit to remove such garbage through the city. The relator owned a stock farm and utilized the garbage as food for animals. In actions instituted by him to compel the issuance of a permit and to enjoin interference with his removal of garbage through the city streets he attacked the above ordinance as being violative of both the State and Federal constitutions. The objections raised against the ordinance were that it denied the right of individual contract and conferred special privileges upon the contractor with the city, thereby creating a monopoly with respect to the garbage contract; that it permitted property to be taken

with compensation; and that the relator was denied the equal protection of the laws. The action of the city manager in refusing a permit to relator was challenged on the ground that his refusal was arbitrary and based upon mere whim and caprice, and it was contended that the city, having prescribed no conditions upon which permits should be granted, left their determination to the city manager and thereby invested him with legislative power. The supreme court decided that no rights of the relator, under either the State or Federal constitution, were violated by the ordinance or by the city manager's refusal to issue a permit thereunder.—Public Health Reports, July 19, 1929.

Sand and Gravel Requirements for Filters

Results of Investigations by National Sand and Gravel Association

FILTER sands have been found, from experience and laboratory investigations, to be required to possess fairly definite characteristics as to mineral composition, size and grading. They must be able to withstand the disintegrating influences of water, with which they are constantly in contact, and must be properly graded to insure efficient operation.

Sand Requirements.—Experiments have shown, according to Turneaure and Russell in "Public Water Supplies," that fine sands are considerably more efficient in removing bacteria than coarser sands and that within certain limits of size little difference in filtering efficiency is found. Also, finer sands cause a steadier and more uniform action over the filtering area, and disturbances due to scraping the filter are less likely to occur. On the other hand, the finer sands become clogged sooner than coarser ones and therefore involve more expense in cleaning. Allen Hazen in the paper, "Water Filtration at Washington, D. C.," which appeared in the Transactions, Am. Soc. C. E., Volume 57, 1906, page 326, under the authorship of Hazen, Allen and Hardy, established two factors to control the average size and uniformity of filter sands, which have come into general use. These are the "effective size" and the "uniformity coefficient."

Table I—Grading Requirements for Filter Sands Used by Different Cities
Information furnished by Sanitary Divisions of the various cities during 1928

City	Effective Size MM.	Uniformity Coefficient	Maximum Size Sieve Opening MM.	Maximum Size Minimum Per Cent Passing	Minimum Size Sieve Opening MM.	Minimum Size Maximum Per Cent Passing
Atlanta, Ga.	0.36-0.44	less than 1.5	1.0	100	0.20	0.2
Birmingham, Ala.	0.35-0.40	1.50	.....	.....	.....	.....
Buffalo, N. Y.	0.38-0.45	.....	.....	.....	.....	.....
Chicago, Ill.*	0.45-0.60	1.3-1.65	.....	.....	.....	.....
Cincinnati, O.	0.34-0.38	less than 1.70	.....	.....	.....	.....
Cleveland, O.	0.35-0.42	less than 1.70	.....	.....	0.20	1.0
Detroit, Mich.	0.40-0.45	less than 1.60	.....	.....	.....	.....
Grand Rapids, Mich.	0.35-0.44	less than 1.65	0.8	95	0.20	0.2
Hartford, Conn.	0.25-0.35	less than 3.0†	5.0	100	0.13	1.0
Kansas City, Mo.	0.40-0.50	less than 1.65	0.80	90	0.20	0.2
Indianapolis, Ind.	0.35-0.40	1.75-2.00	.....	.....	.....	.....
Louisville, Ky.	0.40-0.50	.....	.....	.....	.....	.....
Minneapolis, Minn.	0.40-0.50	approx. 1.55	.....	.....	.....	.....
New Haven, Conn.	0.25-0.35	less than 2.5	.....	.....	.....	.....
Oklahoma City, Okla.	0.35-0.42	less than 1.65	.....	.....	.....	.....
Philadelphia, Pa.	0.30-0.45	less than 1.75	.....	.....	.....	.....
Reading, Pa.‡	0.27	1.50	.....	.....	.....	.....
Richmond, Va.	0.38-0.45	less than 1.50	0.80	90	0.20	0.2
Sacramento, Calif.	0.33-0.42	less than 1.50	0.80	90	0.28	1
St. Louis, Mo.	0.40-0.50	less than 1.65	1.2	95	0.25	¼
St. Paul, Minn.	0.36	1.75	.....	.....	.....	.....

*Specification for experimental filter. †Special requirements for uniformity coefficient given for different effective sizes. ‡Actual values for sands now in use.

Table III

Sieve No.	14	18	20	30	40	50	60	80	100
Clear opening	0.41	1.0	0.84	0.59	0.42	0.30	0.25	0.18	0.15

Effective Size.—The "effective size" is that size than which 10 per cent of the weight of the sand is finer and 90 per cent is coarser. It is expressed in millimeters and may be found by making a sieve analysis of the sand and determining the theoretical size of screen through which 10 per cent of the sand will pass.

Table III shows the clear openings of certain standard sieve sizes of the American Society for Testing Materials:

Uniformity Coefficient.—The "uniformity coefficient" is the ratio of the size than which 60 per cent of the sand is finer to the "effective size." It will be seen that if all the grains are exactly of the same size, the "uniformity coefficient" will be 1. These factors can be most efficiently determined by plotting a sieve analysis curve.

Specifications for size and grading usually state that no grains shall be larger than some size, generally about 1 mm., and limit the percentage of material finer than a small size, generally less than 1/5 mm. Generally, no requirements as to shape of grain are given except that they should not be flat or elongated, since, so far as is known, rounded or angular grains are equally efficient. Sands having effective sizes ranging from 0.20 to 0.70 mm. are used, but the values most commonly specified range between 0.35 and 0.65 mm. Uniformity coefficients vary from about 1.25 to 2.50, with a maximum of 1.50 to 1.60 as the average requirement.

It is important that the sand grains in a filter bed shall not be disintegrated by the water with which they are constantly in contact. For this reason a good filter sand should be of high silica content. To insure durability of the sand grains, it is generally required that not more than 5 per cent shall go into solution in hydrochloric acid after 24 hours digestion or that the sand consist of at least 90 per cent silica. Most specifications also limit the amount of calcium and magnesium carbonate. The upper limit varies in the different specifications, but it is generally not more than 2 per cent. Some of the specifications place limits on iron, alumina, alkalies, loss of ignition, etc., but most of them do not include these detailed requirements.

Gravel Requirements.—Gravel is used in filters for water purification and also in the treatment of sewage. In water purification the purpose of the gravel is to serve as a base for the filter sand and to permit complete and rapid drainage of the filter. The size and grading, therefore, while important, can be varied over a considerable range. The gravel base is usually prepared in several different layers, each made up of one size of gravel, with the coarsest material on the bottom and the finest material in contact with the sand. Table II gives typical requirements as to grading of filter gravels used in water purifications by several different cities. The same precautions with respect to disintegration of the gravel particles by the water must be exercised as described under filter sands.

Table II—Grading Requirements for Gravel for Water Purification Filters

City	Bottom Layer Thickness of Layer, In.	Bottom Layer Size of Gravel, In.	Second Layer Thickness of Layer, In.	Second Layer Size of Gravel, In.	Third Layer Thickness of Layer, In.	Third Layer Size of Gravel, In.	Fourth Layer Thickness of Layer, In.	Fourth Layer Size of Gravel, In.	Thickness of Layer, In.	Top Layer Size of Gravel, In.
Birmingham, Ala.	..	1 to 2	..	½ to ¾	..	¼*	..	.....	..	.....
Cleveland, O.	..	¾ to 1½	..	¼ to ¾	..	⅛ to ¼	..	1/16 to ⅛	..	.....
Grand Rapids, Mich.	8	2	3	1	2	½	2	¼	2	⅛
Hartford, Conn.	7	1 to 2	2½	⅝ to 1	2½	⅛ to ⅜*	..	.....	..	.....
Kansas City, Mo.	4	1½ to 2½	4	1 to 1½	4	½ to 1	3	¼ to ½	3	1/12 to ¼
Memphis, Tenn.	7	1 to 2½	4	⅝ to 1	2	⅜ to ⅝	2	3/16 to ⅜	3	No. 10 to 3/16 in.
Philadelphia, Pa.	6	1 to 2	3	½ to 1	3	¼ to ½	3	⅛ to ¼	3	No. 12 to ⅛ in.
Richmond, Va.	7	1 to 2½	4	⅝ to 1	2	⅜ to ⅝	2	3/16 to ⅜	1	No. 10 to 3/16 in.
Washington, D. C.	5	1¾ to 2½	6	¾ to 1¾	6	¼ to ¾	2	⅛ to ¼	1	⅛ to ⅛

*Top layer.

Mixing and Coagulation in Water Works Practice

General Theory of Coagulation of Chemicals in Water Purification

By M. P. HATCHER

Sanitary Engineer, Burns & McDonnell Engineering Co., Kansas City, Mo.

ALTHOUGH recognized as an important operation in the water treatment plant, the mixing and coagulation of chemicals has been given surprisingly little consideration in water works literature. There may be an explanation of this condition. Changing conceptions and the lack of comprehensive data on the subject may have contributed to its general neglect. Several investigators have given us information on reaction time and water velocities necessary in a general way to satisfactory results and some information is available on specific methods of mixing and coagulating but it may be said in general that the subject deserves more consideration than it has heretofore been given.

Mixing and Coagulation Defined.—There is some confusion in the use of terms. "Mixing" should be understood to include only the action necessary to adequately mix the chemicals with the water. Since we are dealing with coagulation the chemical is generally termed the "coagulant." "Coagulation" is defined as the process whereby the flocculate precipitate is permitted to unite and coalesce into larger and more rapid settling particles. The "retention period" of a mixing or coagulating unit is the extent of the time required for the water to pass through the device as determined by its displacement. "Velocity" as discussed in connection with mixing and coagulation is understood to represent the average velocity of the water in the cross-section normal to the axis of flow.

The discussion of "mixing and coagulation" will in this paper be confined to that pertinent to the coagulation of chemicals for the purpose of assisting sedimentation and filtration, excluding references to the problems involved in the application of lime in softening plants. The mixing of lime and its attending reactions presents problems which are specific and beyond the scope of this discussion. This paper also assumes favorable chemical and physical conditions known to affect the perfect coagulation of chemicals in the water.

The Baffled Basin.—The baffled basin probably deserves first mention in any dissertation on mixing and coagulating devices. This method has been in continued use since the scheme of coagulation was first conceived and still has many exponents among the designing engineers and plant operators.

There are two general types of baffled basins. The one more generally used is the under-and-over type which consists of a series of vertical passages constructed of wood or concrete in an outer structure usually built of concrete. The water passes from the inlet to the outlet through these compartments passing over and under successive partition walls. In the around-the-end type the axis of flow is horizontal. A smaller number of changes in direction are required in this type resulting in lower total head loss. Restricted passages required to maintain velocities are, however, more economically obtained in the under-and-over type of basin. The loss of head and velocity requirements generally fix very readily the type of baffled chamber to use in any particular plant.

Well defined ranges of velocity and retention period are necessary to the successful operation of this type of coagulating device. The proper velocities according to published data, vary from about .5 to 2.0 ft. per second with current engineering practice favoring velocities of about .7 to 1.0 ft. per second. Satisfactory operation of the baffled chamber requires that the velocities be self-cleaning thus avoiding the inconvenience of frequent removal from service. An alum floc will remain in suspension in a velocity of .6 ft. per second while a velocity of 1.0 to 2.0 ft. per second is required to suspend some of the clay silts and fine sand. It has been found that the coagulation process is simplified in plants along the Missouri River, if grit chambers are provided ahead of the mixing and coagulating basins. The removal of the heavier materials effects a two-fold improvement in the coagulation process. The possibility of deposit at nominal velocities is reduced and a source of interference with reactions is removed.

Langelier in his Sacramento experiments in 1921 reported a more rapid flocculation with velocities up to 1.5 ft. per second and a satisfactory flocculation with velocities up to 2.0 ft. per second. The writer, however, shares the opinion more generally held that such velocities may tend to decrease the size of flocculated particles; the advantage at least does not seem to offset the difficulties and costs attending higher velocities.

Retention period requirements in baffled basins vary from approximately 15 to 30 minutes. Higher temperatures are favorable to the shorter periods where longer periods are provided for the lower temperatures. Operators have found it advantageous to apply the chemicals at some intermediate point in the mixing and coagulating basin, eliminating thereby some of the possibility of destruction of the floc after it has reached its best condition.

The requirements of velocity and retention period impose their limitations on the use of the baffled basin as a mixing and coagulating device. Plant operating capacities may have a 100 per cent seasonal variation. If reasonably high minimum velocities are chosen for low operating rates, the velocities at maximum rates result in high head losses, in the baffled basin, making design both awkward and expensive. Head losses of 4 and 5 ft. are not unusual in this type of design. Head loss variation may be reduced if the mixing chamber is divided into two or more units using the number of units which will provide desirable velocities.

Baffled basins lack also the flexibility that is desired. Velocities in the compartments are fixed by plant operating rates. Variations in the character of the raw water may make desirable a change in velocity. This velocity can be obtained only by the use of the unit plan mentioned which tends to increase costs of structures. These shortcoming have led in many cases to the choice of other methods of mixing.

Mechanically Agitated Plant.—Coagulation is accomplished in a large number of water treating plants by mixing the applied chemicals with the raw water in tanks agitated by mechanically operated paddles. Flexibility in mixing velocity may be obtained by the provision for varying speeds in the stirring mechanism. Retention periods may be varied by the series or parallel operation of several tanks. The head loss through these units is of course small.

Velocities and retention periods in the mechanically agitated tank are made to conform to the requirements mentioned for the baffled chamber, the nominal velocity being assumed as that at the two-thirds radius point. Published data indicate that efficient mixing is obtained when the paddle area is 25 per cent of vertical cross sectional area of the tank. The writer knows of instances where satisfactory results are obtained with a single propeller type of paddles at the bottom of the tank. Several different arrangements of inlet and outlet have been used with success but theoretical considerations indicate that center inlet with circumferential take-off is preferable.

The Hydraulic Jump.—The hydraulic

jump has been studied with reference to its adaptability to the function of mixing by J. W. Ellms. The hydraulic jump may be described as the manner in which water is conveyed in restricted channels to a lower level with a consequent dissipation of energy through internal impact. The turbulence of the water at the jump brings about a condition which is ideal for the mixing of the small volume of chemical solution with the much longer volume of water. While the retention period is estimated to be only about 30 seconds the chemical reaction has been shown by experiments to be quite complete. The loss of head through the jump is less than that ordinarily required in the baffled basin, maximum efficiencies being claimed for head losses of .75 to 1.0 ft. This device is in use in a number of plants.

Spiral Inward Flow Method.—Mixing of chemicals and water is accomplished in a few plants by a method generally described as the spiral inward flow. Water is applied tangentially in a circular tank and is removed through a tap or bottom outlet pipe at the center. The arrangement of inlet and outlet causes the water to follow a spiral path from the periphery of the tank to the center. The displacement volume of the tanks provides in cases where this device has been used, a retention period of about 30 minutes. The water in following the spiral path from the periphery to the center moves with increasing velocity to the outlet. Considerable turbulence is produced by the swirling motion at the center just as the water is leaving the tank. Head loss requirements in this type of mixing device vary with the velocities obtained, allowances generally made ranging from 1 to 4 ft.

The types of mixing and coagulating devices in most general use have been enumerated and described. There are other devices, however, that should be mentioned briefly. The centrifugal pump, though not readily recognized as a mixing device, is sometimes used as such. Chemicals are applied in the suction and are mixed by the turbulent agitation produced in the pump. Mixing in some plants is accomplished by application of chemicals to the inlet lines to the settling basins. The Chain-of-Rocks filtration plant at St. Louis uses as a mixing device a series of underground concrete conduits wherein suitable velocities and retention are obtained. One manufacturer offers a mixing device which employs mechanical agitation with modifications of the usual methods. Another suggests the use of a device used in sewage disposal as an aerator. Practice indicates that some degree of coagulation can be obtained by a large variety of methods.

In order that we may more satisfactorily solve the problems of mixing and coagulation it is desirable that we analyze the processes involved with a view to determining the conditions most suitable to their accomplishment. The results of experimentation and practical operation now available should enable us to draw some general conclusions.

The original investigations of the hydraulic jump as a mixing device made by Mr. Ellms in about 1920 in connection with the report on water treatment at Milwaukee were reported without reference to the use of any adjunctive provision for coagulation. Nor was this need suggested in the earlier recommendations for its use. Excellent agitation was produced by the action of the hydraulic jump and it seemed reasonable to assume that a rapid and thorough distribution of the chemicals in the water might improve the process of coagulation. It is quite significant that the chemical reaction is completed in the hydraulic jump in the short time of 30 seconds. The contrast with the 30-minute period of the baffled basin pointed to distinct advantages for the hydraulic jump.

Later developments suggest a more complete analysis of the phenomena of mixing and coagulation. The experience of the writer has indicated that perfect coagulation requires something more than a completed chemical reaction. Mr. Ellms states in his later deductions that "gentle agitation produced by a velocity of flow from .75 to 1.0 foot per second hastens floc formation and produces a good aggregation of finely divided particles in 5 or 6 minutes."

Complete Coagulation Two Separate Steps.—The writer submits that complete coagulation should be considered as a process of two separate and distinct steps: (1) The chemical reaction of the coagulant and the treated water, (2) the physical change involving the aggregation of the flocculent precipitate and that overlapping of these two steps will not permit the best results. The first step is accomplished by any method which will bring the coagulant in close contact with all the water. This requirement points readily to violent agitation. The second step is accomplished best in velocities which will barely keep the floc in suspension. It is evident that violent agitation would be detrimental to the aggregation of floc and it is apparent that the chemical reaction would not be accelerated by the slow velocities favorable to the formation of the floc. It appears that only 5 or 6 minutes of gentle agitation are required to produce perfect coagulation after the chemical reaction has been completed. Since 15 to 30 minutes are required for complete coagulation in the baffled basin or mechanically agitated tank, we may reason that the first 10 to 25 minutes in these devices are consumed in bringing about the first step or chemical reaction which is completed by violent agitation in 30 seconds.

It is interesting to consider the methods employed in the devices described in relation to the method prescribed in a manner by the analysis of the general theory of coagulation as presented. If the chemical reaction can be completed in 30 seconds of violent agitation then excess capacities are being provided in baffled basins and mechanically agitated tanks where the same function is accomplished in a much longer time. The hydraulic jump appears to perform only the first step in the process. If the mixing process is followed immediately by the settling basins, the slow velocities therein will permit some of the floc to settle out before its full usefulness is developed. It seems desirable that a short period of gentle agitation follow this device. The spiral inward flow basin with a much larger capacity performs a service equivalent to that of the hydraulic jump but is not as efficient in the writer's opinion with equal energy losses. The action in this type of mixing device is, in fact, just the reverse of that desired for mixing and coagulation. The turbulent agitation is produced at the outlet where gentle agitation is required to preserve the floc. Low velocities prevail at the inlet where turbulence is desired.

Lack of uniformity in the fundamental principles of the mixing and coagulating devices in use indicate the necessity of further experimental study of these principles. The general theory of mixing and coagulation as outlined in this paper has served the writer as a means of comparing and studying the methods advanced from time to time.

Acknowledgment.—The above paper was presented at the 11th Texas Water Works Short School.

National Water Works Corporation Purchases $4,000,000 of Properties.—The National Water Works Corporation has acquired new properties valued at more than $4,000,000 in West Virginia, New Jersey and Pennsylvania. One company purchased was acquired from the United States Steel Corporation. This is the Mount Pleasant Water Co., organized in 1881, serving Mount Pleasant, Pa. Other Pennsylvania properties acquired are the Citizens Water Co. of Scottdale and the Gettysburg Gas Co. The West Virginia companies include the Buckhannon Water Co., Kingwood Water Co. and the Philippi Water Co., serving towns of the same name. In New Jersey, the Riverton & Palmyra Water Co. has been acquired.

Water Supplies in Michigan.—There are 331 public water supplies in Michigan, of which 112 are surface supplies. Fifty-two of these supplies are protected by chlorination only and an additional 27 are filtered. An additional 21 supplies are not supposed to be used for domestic purposes, being essentially fire protection supplies, mostly in small places.

Preammoniation at the Water Purification Plant of Springfield, Illinois

Experiences in Use of Ammonia As a Preventive of Chloro-Tastes

By CHARLES H. SPAULDING

Chief Chemist, Water Purification Plant, Springfield, Ill.

SINCE February, 1928, the Springfield water purification plant has used ammonia as a preventive of chloro-tastes with very satisfactory results. Prior to that time we were sometimes troubled with slight tastes associated with chlorination. While these were usually not sufficient to cause serious complaint, they did occasion remarks from time to time and left an opening for unfavorable criticism. Soon after beginning the ammonia treatment, we received a number of voluntary compliments on the improved taste of the water and occasionally find the impression that no chlorine is used at the Springfield plant.

The use of ammonia as an aid in disinfection is mentioned in standard texts. As a taste preventive, however, McAmis, at Greeneville, Tenn., seems to have been the first to use ammonia.

Preliminary Experiments at Springfield.—The bacterial loads in the raw water at Springfield have been excessively heavy. It was important in our case, therefore, that nothing should be done to lower the efficiency of chlorination, but that everything possible should be done to increase it. Some laboratory tests were then made to determine how disinfection would be effected. I used a pure culture of B. Coli added to samples of boiled distilled water and also to raw river water. In each case the disinfection accomplished in one hour was greater when ammonia was added to the water just before chlorination. The results on distilled water and raw water are shown in Table I.

These results were very encouraging, for preammoniation would thus rank as an additional measure of purification as effective in removing bacteria as other stages such as coagulation or filtration. However, we were disappointed in our next experiments in which lime was used as well as chlorine and ammonia.

Table I—Effect of Preammoniation on Disinfection with Chlorine

	Pounds per Million Gallons Ammonia	Chlorine	B. Coli per Cubic Centimeter After 1 Hour	Per Cent Remaining After 1 Hour	Residual Chlorine
			Boiled Distilled Water		p.p.m.
A	0	0	29,500	100	
A	0	1.0	535	1.8	
A	0.5	1.0	20	0.07	
B	0	0	15,000	100	0
B	0	1.0	50	0.3	0.10
B	0.5	1.0	5	0.03	0.10
			River Water		
	0	0	39,000	100	0
	0	4	13,600	35	0.06
	2	4	650	1.7	0.06

Table II—Effect of Preammoniation on Chlorination of Lime Treated Water

Pounds per Million Gallons Lime	Ammonia	Chlorine	Total Count per Cubic Centimeter	Per Cent Remaining	Residual Chlorine p.p.m.	Alkalinity Phthalein	Alkalinity Total
0	0	0	25,500	100	0.0		194
1,200	0	0	24,500	96	0.0		
1,200	0	5	875	3.4	0.20	50	76
1,200	1	5	875	3.4	0.20	50	74
1,200	2	5	2,400	9.4	0.23	50	76
1,200	3	5	2,450	9.6	0.26	55	80
1,200	4	5	3,250	12.7	0.30	43	74

In this case the results after one hour of contact were less satisfactory with ammonia than without. The data on one group of tests with lime, ammonia and chlorine are shown in Table II.

The water used in this case was river water having a total count of 4,300 per cubic centimeter, to which a broth culture of B. Coli was added sufficient to give the initial count of 25,500 per cubic centimeter. Thus the organisms added greatly predominate, although they are not in pure culture. Lime, ammonia and chlorine were added in the order named while the samples were being stirred in a stirring machine for 5 minutes. They were then allowed to stand 55 minutes, after which stirring was resumed for 5 minutes and the samples taken up into the pipettes while being agitated. Alkalinities and residual chlorine were determined after plating out the bacterial samples.

The fact that a moderate causticity has little effect on B. Coli reduction in 1 hour is illustrated by this set of samples which was treated and titrated at room temperature. We have since found that no conclusions as to lime sterilization are valid unless temperature is stated, but in this case all samples were from the same batch and of the same size, and run at the same time, so that any temperature changes were of the same magnitude. Therefore, the comparison is accurate enough for the present purpose.

This experiment was twice repeated and samples taken at intervals up to 6 hours. The results confirmed the previous tests in general, but the indications were that still further reductions would be obtained with longer contact, and a fourth set was carried through to 21 hours and sampled five times during the run. The results in this set are shown in Table III.

As before, diluted broth culture of B. Coli was added to raw river water. The total count of the raw water before addition of the broth culture was 3,700 per cubic centimeter, and after the addition, 32,000. The results cannot be said to represent B. Coli efficiencies strictly for that reason. However, these comparisons have been made at times when the initial count of the raw water was only 0.5 per cent of the B. Coli added. The trend is always the same. Chlorine works best at lower pH values, that is, without lime. The addition of lime slows the chlorine sterilization, and the further addition of ammonia retards it still more. Yet in eight hours the four chlorinated samples have reached nearly the same point. Lime by itself is very slow in comparison. In this case the alkalinity was determined only at the end of 21 hours, and the water was exposed to recarbonation throughout the run. The alkalinity at the end indicates from 5 to 25 p. p. m. causticity and values of pH above 10 at least at the beginning of the run.

From these experiments it is evident that the best time to apply chlorine is prior to the addition of lime. It is plain that, if ammonia is used, a very marked increase in efficiency will result, providing the sterilization is complete before the addition of lime. It was not practical to realize these advantages without considerable additional capital investment at Springfield, and they were not attempted. The next best procedure is prechlorination to allow the maximum period of contact. Ammonia can be used in small amounts provided the contact period is sufficient. If the ammonia permits higher chlorine residuals without taste, then the retarding effect may be more than balanced by the free use of the sterilizing agent.

At Springfield, the nominal detention periods in the various stages of purification are as follows:

Mixing chambers		40 minutes
Clarifiers	1 hour	40 minutes
Settling basins	4 hours	
Carbonating chambers		30 minutes
Filters		30 minutes
Clear well (full)	4 hours	
Nominal total	11 hours	20 minutes

The actual flowing through time may be much less for a part of the water or for all of the water under certain circumstances such as low clear well or

Table III—Relation of Contact Period to Bacterial Reductions in the Lime-Ammonia-Chlorine Treatment
(Temperature Constant at 17.5°C.)

Pounds per Million Gallons			Per Cent Remaining							
			Hours Contact							Alkalinity
Lime	Ammonia	Chlorine	1	2	4	8	21	Residual Chlorine	Phthalein	Total
0	0	0	100	103	91	88	106	0.0		197
1,200	0	0	69	75	66	59	17	0.0	35	65
0	0	4	22	1.1	0.9	0.6	0.5	0.02		197
1,200	0	4	44	16	2.7	0.7	0.5	0.09	30	60
1,200	1.0	4	31	33	6.6	0.7	0.5	0.11	32	62
1,200	2.0	4	56	35	17.0	0.9	0.5	0.12	31	64

basins out of service. However, the plant is being operated at about 60 per cent of its capacity, so that the above figures should not be far from the facts on the average.

Four Classes of Tastes.—It was hard to establish definitely the sources of taste at Springfield for the tastes were not distinct as a rule. They were seldom sufficient to permit agreement by any two observers as to their quality, and for the most part passed unnoticed. Yet I believe we can now distinguish four classes. First, there was, occasionally, a medicinal taste at remote points on the distribution system sufficient to make the water unpalatable and to give credence to those who somewhat vaguely described a taste at other times. Second, a moldy chlorinous taste appeared occasionally after showers, usually associated with higher turbidity and higher chlorine dosage though not necessarily higher chlorine residual. A third class of tastes is associated with sudden thawing of ice over a large area of watershed following a sleet storm or frozen flood conditions. This is naturally rare, but may be extremely disagreeable. The fourth class of tastes is derived from algae and is not affected by ammonia treatment so far as we now know. With the possible exception of the first class, all of these are more correctly described as odors.

Under the circumstances it seemed as well to try the ammonia first on a plant scale, since it is simply applied, cheap and harmless, whether effective or not. The results were noticeable at once. The dose of ammonia was set at 5 lb. per day treating 7 million gallons of water. The quantity has been sufficient with the exception of a few brief periods when double the amount was used. During these periods it was possible to get a better idea of the effectiveness of the ammonia treatment through laboratory experiments which were made accordingly. For example, one set of bottle experiments is shown in Table IV.

Table IV—Experimental Treatment—Taste Prevention
(Temperature Maintained at 6°C.)

Sample Number	Chlorine, pounds	Ammonia, pounds	Taste After 40 Minutes	Odor After 40 Minutes	Residual Chlorine p. p. m.
1	6	0	2	1	0.20
2	6	1	1	0	0.23
3	6	2	0	0	0.26
4	8	0	3	3	0.30
5	8	2	1	0	0.35
6	8	3	0	0	0.40

Note: 1,200 lb. of lime and 200 lb. of alum were used in each case.

Samples were treated with chemicals as in the plant, except that chlorine and ammonia were varied. It is not possible to give a numerical value to taste with our present knowledge, and the figures in the taste and odor columns simply give the writer's opinion of the relative magnitudes. But where zero is recorded, all of several observers agreed taste was absent, while the value 3 indicates the consensus of opinion as to the worst of the group. Moldy and chlorinous would best describe the quality. The plant treatment on this day was 9.2 pounds chlorine and 1.6 pounds ammonia per million gallons, and no taste was present in the plant effluent. The experiment demonstrates that this class of tastes and odors is prevented at Springfield by the use of ammonia. Similar experience has been described recently by Harrison at Bay City.

The taste described as medicinal develops more slowly and is difficult to catch at the plant. A 24 hour composite sample of raw water, however, was examined by Mr. Theriault, chemist, United States Public Health Service, who reported a recovery of 1.2 parts per billion of phenol, and the fact that this amount is sufficient to cause a chlorophenol taste. Subsequently I have treated boiled distilled water with phenol in amounts from 2 to 50 parts per billion and have found that ammonia effectively prevents chlorophenol taste when used in the ratio of ½ lb. ammonia to 1 lb. chlorine. This conclusion is at variance with that of Harrison, whose results with ammonia in chlorophenol taste prevention were negative. There are several points of difference, however, in the way the experiments were made which may explain the discrepancy. He has used larger amounts of phenol and does not state what sort of water was used in the test. If it was not phenol-free, the difference in quantities might be still greater. Furthermore, in our case, lime water was added to the distilled water sufficient to produce a pH value of 9.6, which would approximate our plant effluent. Since pH makes a considerable difference in the activity of the chlorine, it may also affect the taste production. This point would stand further investigation. In our case cited the chloro-phenol taste developed somewhat from the start, but after 24 hours in the refrigerator it was very decided and roughly proportional to the phenol added. The samples pretreated with ammonia were entirely free from taste. These experiments and the plant experience indicate that, in a softening plant at least, ammonia may and in our case does prevent chloro-phenol taste.

No laboratory experiments have been made on the thawing ice complex which has occurred only once at this plant. As soon as discovered, the ammonia was increased from 0.7 to 1.7 lb. per million gallons in the raw water, after which the odor disappeared. The chlorine dose at this time was 7 lb. per million gallons. The following day complaints were received of the odor from hot water faucets. We are not sure whether this could have been entirely prevented by an earlier increase in ammonia dosage. There was no suggestion of chlorine in the odor. Using the hot test, both raw and filtered water will usually have some odor, more intense in the raw than in the filtered. For these reasons no definite conclusions could be drawn, but we were certain that the odor and taste of the cold water were immediately improved by increased ammonia.

Effect on Plant Operation.—It was shown by the preliminary experiments that no increased efficiency could be expected directly from preammoniation at this plant, but if chlorine could be used more freely, then indirect benefits might accrue. Table V includes the pertinent data summarizing the effect on plant operation.

It will be seen that chlorine consumption has increased, due to chlorinating raw water and due to the higher residual. On the other hand, less coagulant was used during the past year than previously. The net result is a saving of 41 ct. per million gallons treated, or 29 ct. if the cost of ammonia is included. The time required for disinfection is sharply brought out in the comparison of bacterial results at various stages in the process. For example, the clarifier effluent in the past year showed 33 per cent of the B. Coli index of the previous year. The water applied to the filters contained 16 per cent of the previous index, while the filtered water contained only 5.5 per cent of the former figure. The improvement practically stops at this point since the final chlorination now merely fills any sags in the chlorine residual.

Secondary Contamination.—In the tabulation for 1928-1929, the B. Coli

Table V—Comparison of Plant Records
Fiscal Year, March-February

	1927-1928	1928-1929
Number months prechlorination used	1	12
Total chlorine used, pounds per m. g.	2.9	6.1
Residual chlorine final, p. p. m.	0.12	0.18
Ammonia, pounds per m. g.	0.06	0.72
Coagulant, pounds per m. g.	135	82
Turbidity, p. p. m.:		
Raw	111	99
Applied	7.6	7.2
Filtered	0.04	0.01
B. coli per 100 cc.:		
Raw	19,757	21,122
Clarified	187	62
Applied to filters	134	22
Filtered	12.3	0.68
Chlorinated	0.36	0.25
City tap	0.12	0.11

index of the final effluent has had to be corrected and a considerable number of positives thrown out for the following reasons. The sudden appearance of B. Aerogenes in the discharge of a high service pump led to the discovery that the packing of this pump was contributing quantities of bacteria which in the ordinary routine would be classed as B. Coli. These bacteria, grown on Levine's eosin methylene blue agar, gave large convex confluent colonies usually with metallic sheen, when present, limited to small central area, the colonies appearing brown by transmitted light. The bacteria were non-sporing rods. Without carrying the identification further, I felt justified in classifying these as B. Aerogenes. From a sample of the packing taken from the pump, I estimated twenty billion B. Aerogenes per pound. New packing was then examined and found to contain the same organisms in great abundance. Eventually a packing was secured free from these bacteria, but meanwhile much water had gone through the pump. However, due to the chlorine residual maintained with the aid of preammoniation, the water from city taps showed very few of these bacteria. For example, one monthly record shows the following:

B. Coli Indices, August, 1928

Pump suction	0.15
Discharge	1.4
City tap	0.13

While these particular bacteria had no sanitary significance in our opinion, the case is cited as an illustration of the disinfecting effect of the residual chlorine which averaged 0.23 p. p. m. during the month. The effect is particularly valuable at this plant, located as it is on the bank of a river in which the B. Coli index is frequently over 100,000 per 100 cc. The clear well and flow lines extend below low water stage and much of the structure is surrounded with cinders or other loose material. Under flood conditions they are under as much as 18 ft. of pressure from without. A leak of 50 to 100 gal. per day would reduce a sterile water below standard unless it carried some protection.

Application of Chlorine and Ammonia.—The program which has finally been adopted with reference to chlorine and ammonia is as follows: Ammonia is added at the rate of 0.7 lb. per million gallons at the inlet of the raw water dosing well, where the detention is about 30 seconds. Chlorine is applied at the outlet of the dosing well in amount sufficient to produce a residual of 0.2 to 0.3 p. p. m. in the effluent of the clarifiers. As a rule, the residual drops slightly by the time the water has passed the filters, and additional chlorine is then added to bring the residual back between 0.2 and 0.3 p. p. m. If no drop has occurred, the second chlorination is omitted. As a rule, 1 lb. per million gallons is sufficient at this point.

The application of the ammonia has been made by solution prepared from anhydrous ammonia and delivered to the water from a small orifice below a tank holding 190 gal. of solution containing from 10 to 20 lb. of the gas. However, the present practice is to apply the gas directly through a needle valve and a bubble meter consisting of a bottle of light oil through which the gas rises. In this arrangement the rate is regulated by the number of bubbles per minute, 280 bubbles per minute being equivalent to 5 lb. per day. The rate of flow is extremely constant, the valve frequently requiring no adjustment over a 24 hour period. The capacity of the device as at present is about 10 lb. per day, which is the maximum and exceptional amount used. The ammonia tank stands on a scale, and the weight is recorded at regular intervals. The gas enters an alum solution line through which a small stream of water carries it into the dosing well. Whether or not the alum line is carrying coagulant is of no consequence.

Ammonia can be bought in many forms. Salts of ammonia could be applied from a dry feeder, but we have found the cost per pound of NH_3 is less for either aqua ammonia or anhydrous ammonia, which are very nearly the same delivered at Springfield, namely 15 ct. per pound.

In view of the advantages which we have found in preammoniation, either for taste prevention or for increased efficiency where lime is not used, this useful addition to water purification processes should find wider application. The method employed formerly was to prepare chloramine solution before addition to the water, and this troublesome procedure probably prevented more general use.

When Preammoniation Would Be Advantageous.—Bulletin No. 21 of Illinois State Water Survey contains analyses of municipal well supplies in Illinois. Taking the first hundred as typical, I find 23 per cent have less than 0.1 p. p. m. of NH_3. In chlorinating such waters, preammoniation will doubtless be found advantageous at times. On the other hand, the remaining 77 per cent contain up to 36.1 p. p. m. free ammonia as NH_3, with an average of 3.36 p. p. m., equivalent to 26.5 lb. ammonia per million gallons. Obviously it would serve no useful purpose to add ammonia to such water, although the knowledge of the ammonia content should throw considerable light on the behavior of chlorine in the water.

As compared with well waters, the rivers of Illinois are notably uniform in free ammonia content. Bulletin No. 5 (1907) of Illinois State Water Survey contains tabulations of sanitary analyses of municipal supplies, and I have arranged the ammonia data applying to surface waters in Table VI.

It will be seen that the average of each of the six stations is not far from the average of all, and the maxima and minima are not greatly divergent. A number of determinations which I have made on the Sangamon River at Springfield show but little variation from the value 0.090 p. p. m. N as free ammonia. Lake Michigan at Evanston, according to the above bulletin, contains slightly less than half as much free ammonia as the streams. We should expect, therefore, that, in general, the surface waters of the state will respond to preammoniation.

Conclusions. — Preammoniation increases the efficiency of chlorination of water having normal pH value and low ammonia content.

Preammoniation prevents chlorotastes, including chloro-phenol tastes in a lime softening plant.

With high pH values, considerable time of contact, as much as eight hours, should be provided if maximum sterilization is required.

Ammonia is simply and cheaply applied with no undesirable after-effects necessitating special vigilance.

Chlorine residuals sufficient to overcome subsequent contamination are feasible when ammonia is present.

Acknowledgment. — The foregoing was presented May 14 before the Illinois Section of the American Water Works Association.

Table VI—Nitrogen as Free Ammonia in Surface Waters of Illinois
Results in Parts per Million

	Average	Maximum	Minimum
Sangamon River at Decatur	0.094	0.272	0.008
Vermilion River at Danville	0.070	0.144	0.024
Kankakee River at Kankakee	0.087	0.184	0.016
Vermilion River at Streator	0.090	0.344	0.008
Mississippi River at Quincy	0.114	0.300	0.048
Mississippi River at Moline	0.071	0.176	0.040
Averages	0.088	0.237	0.024
Lake Michigan at Evanston	0.040	0.082	0.012

Water Works in Illinois.—There are public water systems in 507 municipalities of Illinois serving 4,956,698 people. Of these systems 441 are municipally owned and 66 are privately owned. The total number of supplies is 469, as in some cases two or more municipalities are served from one supply. A summary of supplies classified as to source is as follows:

Wells	369
Surface	79
Springs	9
Wells and surface	5
Wells and springs	2
Miscellaneous (mines and quarries)	5

Sludge Disposal at the Calumet Sewage Treatment Works

Experiences at the Imhoff Tank Plant of Sanitary District of Chicago

By A. H. GOODMAN and C. E. WHEELER

Respectively Plant Sanitary Engineer, and Assistant Plant Sanitary Engineer, Calumet Sewage Treatment Works, Sanitary District of Chicago

THE Calumet Sewage Treatment Works of the Sanitary District of Chicago, located at 125th St. just west of Cottage Grove Ave., is designed to treat the sewage of Chicago south of 87th St. and in addition, that of Blue Island, Riverdale, Dolton and several other small municipalities at some future period. The combined (domestic and storm water) sewage is brought by intercepting sewers to two pumping stations, one at 95th St. near the lake and the other at 125th St. and Michigan Ave. The flow from the latter station comes to the treatment works. The design capacity of the plant is 56 m. g. d. with an allowance for a 50 per cent increase for storm flow.

The sewage is measured by a Venturi meter and then passes through a rack screen with 1-in. openings equipped with a mechanical cleaner. It flows next through grit chambers which are equipped for cleaning with a grab bucket on an electric hoist working from a gantry crane. The velocity in the grit chamber is maintained between 0.75 and 1 ft. per second. The sewage then passes to 30 Imhoff tanks each 103 ft. 6 in. long by 34 ft. 6 in. wide, and 25 ft. deep. The sedimentation compartment is divided into 3 bays. There are 3 sludge hoppers in the shape of inverted frustrums of square pyramids. Gas vent area is 17 per cent of the total surface area.

Operation of Tanks.—Operation of the plant began on Sept. 12, 1922, when sixteen Imhoff tanks were put into service. The remainder of the Imhoff tanks were started on Dec. 16, 1922. The sewage treated is mainly domestic and somewhat weak in character. In 1924, however, paint waste began to cause trouble. Large quantities of oil are found at times. No foaming trouble has been noted from the sixteen tanks started in September but the tanks started in December went through a violent foaming period of about six weeks the summer of the next year, 1923. Since 1923 there has been no foaming in any of the tanks.

The tanks are arranged so that the direction of flow may be reversed. This is done regularly, the length of time in one direction rarely exceeding 2 months. This program appears to give satisfactory distribution of solids throughout the length of the tanks. Routine determinations of sludge levels are taken at 3-month periods in each hopper. These levels are taken with a common pitcher pump, equipped with a suction hose, which is lowered through the supernatant liquor underlying the scum in the gas vents until sludge is encountered. This method has proved to be the most dependable of any tried.

Sludge Removal Machine at Calumet Sewage Works

Disposal of Imhoff Sludge.—Sludge is removed from the sludge hoppers by an air lift. Water rings of perforated brass pipe are installed in each sludge hopper to stir up heavy sludge and to aid its movement, also to allow of some mixing of the digesting sludge mass. After being pumped from the hoppers the sludge runs by gravity to the original drying beds, which are adjacent to the tanks, or to two—150 gal. per minute Jennings pneumatic ejectors, which force the sludge to the additional beds installed in 1927. The total sand bed area at the present time is equal to 0.67 sq. ft. per capita on the designed population of 225,000 people or about 1.0 sq. ft. per capita on the present population. Sludge as wasted varies in moisture from a yearly minimum of 87.2 per cent water to a yearly maximum of 89.1 per cent. Average moisture of sludge over five years of operation has been 87.8 per cent.

Sludge is usually placed on the beds to an average depth of 9 to 11 in. At certain times of the year, in order to use the drying area to greater advantage, the depth is increased to 15 to 16 in. Filling 9 to 11 in. in average good drying weather permits the sludge to be removed from the beds in about two weeks, with a yearly average moisture content varying from 39.3 to 55.1 per cent. Sludge has been removed by hand with forks and carried away by a system of narrow gage railroad tracks and dump cars. The original sand beds are 66 ft. long and vary in width from 17 to 20 ft. The 24 in. gage industrial track is installed lengthwise in the center of each drying bed with a complete system of switches and main track for assembling trains outside. The new beds are 105 ft. long and 65 ft. wide with a similar track system going into the beds, 5 rows of track to each bed, making the distance between center line of tracks 22 ft. Motive equipment consists of three Plymouth industrial gasoline locomotives and forty ¾-yd. dump cars.

The sludge is removed from the beds by hand forking into the cars, the cars are assembled and hauled to a sludge pump for disposal at the north end of the property. This dump was built up on the clay spoil from the plant construction and is about 700 ft. long. The track is laid the long way of the dump. As the sludge accumulates it is pushed over the edge of the bank by a Parson's backfiller. This has facilitated greatly the handling of sludge at the spoil bank, and with the improved distribution the track must be moved not more than once per year.

Some figures on sludge quantities and analyses may be of interest.

Imhoff Sludge Removal Data

Year	Wet Sludge Pumped from Tanks		Dry Sludge Removed from Beds	
	Total Cu. Yd.	Moisture, %	Total Cu. Yd.	Moisture, %
1923	7557	87.2	3289	44.1
1924	13039	87.3	3938	41.2
1925	16073	89.1	7080	46.7
1926	18323	87.3	7524	51.3
1928*	13999	88.1	6014	55.1
1927	19864	87.5	7990	39.3
Total	88855	526.5	35835	277.7
Av.		87.8		46.3

*Plant shut down 4 months.
Total dry solids removed for six years—34,243,630 lb.
Dry sludge weight per cubic yard as removed 1,500 lb.

Sludge Analysis

Sample and Year	Moisture, %	Nitrogen, %	Volatile, %	Fixed %
Sludge from beds—'24	53.3	1.68	41.6	58.4
Sludge dump top—'23	43.3	1.33	32.8	67.2
Sludge dump intr.—'23		0.98	27.9	72.1
Sludge from beds—'27	52.45	2.00	40.2	59.8
Sludge dump top—'26	30.22	1.48	38.7	61.3
Sludge dump intr.—'26	46.86	0.99	42.6	57.4

Record of Temperatures, Imhoff Tanks.—The lowest average monthly temperature in the sludge compartment over the period of our record has been 40° F., which has also been the lowest temperature for the flowing-through compartment. The maximum for the sludge compartment occurred in September, 1926, and was 70° F., while the maximum for the incoming sewage on several occasions during August and September has been 69° F.

For the three years over which we have complete records the following condition prevailed.

No. of Months	1925	1926	1927
Below 50° F.	5	4	2
Above 50° F.	7	8	10
Above 60° F.	4	6	4

These figures indicate that in Chicago and vicinity for an average of 4 months per year temperatures in unheated digestion tanks will be so low as to retard digestion processes very noticeably.

Digestion of Settled and Activated Sludge.—Digestion of primary sludge and excess activated sludge has been studied on a large scale. These tests extended over a period of three years. An average of 1.75 m. g. d. of sewage was settled in an Imhoff tank and the effluent was treated by the activated sludge process. The waste activated sludge was returned to the incoming sewage of the Imhoff tank.

After six months of operation it was apparent that additional sludge digestion capacity was needed to provide storage for the bulkier sludge from the activated sludge process. An additional Imhoff tank was used to supply the extra capacity required. This was operated as a separate digestion tank. The partially digested sludge was pumped over into this second Imhoff tank where the digestion was allowed to continue until the sludge was in satisfactory condition for drying.

The activated sludge was wasted as slowly and as gradually as possible, in order to obtain as nearly as possible continuous mixing of activated with fresh sewage solids in the Imhoff tank. Occasionally the flow of activated sludge had to be shut off so as not to withdraw too much from the activated sludge process. The combined sludge after digestion had all of the characteristics of Imhoff sludge produced at the plant except that it averaged about 2 per cent higher in moisture content as drawn, contained somewhat higher total nitrogen, and cracked into much smaller sections in drying.

Average figures for the entire period of experiment gave the following results: 9.4 cu. yd. per m. g. of activated sludge at 98.55 per cent moisture mixed with 2.2 cu. yd. per m. g. of fresh sewage solids at 90 per cent moisture (est.) gave 2.4 cu. yd. per m. g. of combined sludge at 89.8 per cent moisture. This amounts to an 80 per cent reduction in volume. The digestion of dry solids was based on determinations of suspended solids in the influent and effluent of the Imhoff tank and on the actual quantity of activated sludge wasted. These data over a long period indicated 32.5 per cent digestion of suspended solids.

This experiment at the Calumet Sewage Treatment Works indicated the practicability of satisfactory digestion of Imhoff and activated sludges. This procedure was adopted in the design of the West Side Treatment Works, where the waste activated sludge of the North Side Treatment Works will be mixed with the fresh incoming sewage of the West Side plant and the mixed settled solids digested.

Mechanical Removal of Sludge.—Mechanical sludge removal from drying beds became important to the Sanitary District with the development of the West Side project. Experimental work has been carried on at the Calumet plant for the last 3 years to help in the solution of this problem. Small-scale work was started with a roughly built cleaner which worked on a narrow gage platform car. This consisted of a set of fingers bolted to a sheet metal tray equipped with an angle-flight elevating mechanism for moving the sludge up the pan to the dumping position. The machine was pulled through the bed by a car-puller. The width of the strip taken was approximately 4 ft. This machine demonstrated the feasibility of the plan and the fact that sludge could be taken off a drying bed mechanically without removing excessive quantities of sand with the sludge.

The next development was a machine of quite similar principle with a span of approximately 16 ft. Different shapes of elevating angles were used.

In the fall of 1928 a practical working machine was constructed to operate over six of the new sludge drying beds (105 ft. x 65 ft.). This machine is a double truss structure spanning the width of the beds and supported by rails on side walls. The narrow gage track system was removed from the drying beds. The machine traverses the total length of the six beds. The equipment is completely motorized, receiving its power from a trolley system extending lengthwise of the beds.

The machine was developed by the Evers-Sauvage Engineering Co. It consists of a series of specially shaped buckets working on an endless vertical chain quite similar to a ditch digging machine. The buckets are equipped on their cutting side with sharpened teeth and cut a strip of sludge about 4 ft. wide across the narrow dimension of the beds. The carriage carrying the buckets moves into the sludge by a drive which is independent from that which runs the bucket elevator. The buckets dig into the sludge at a speed of 20 ft. per minute. The speed of the elevator is sufficient to raise the sludge as rapidly as it is forced into the buckets. The buckets dump into a short cross belt conveyor which in turn discharges onto a large belt which travels across the width of the bed and discharges into the narrow gage dump cars. These cars are pulled along by a gasoline locomotive as the sludge machine moves forward on the bed.

In some preliminary tests that have been made on the machine this summer the capacity on sludge of about 55 per cent moisture and from 5 to 6 in. deep appears to be about 1.25 cu. yd. per minute. The buckets can be elevated or lowered to strike the exact sand level. They appear to pick up an almost negligible quantity of sand. There are several ways in which the capacity of this machine may be increased.

Collection of Gas from Imhoff Tanks.—Closely connected with the problem of sludge disposal is the collection of gas from digesting sludge. One Imhoff tank was equipped with gas collectors in the gas vents, the total number of separate vents covered being 24. Half of these were equipped with collectors of the Imhoff type consisting of a submerged collector sloping upward from ends to center where a small opening is provided, covered with a screen of loosely laid tongue-and-groove material. This screen is to hold back scum and permit the passage of gas into the small collecting can. The Sanitary District type consists of a longitudinal sheet metal collector, which covers the whole gas vent area. There is a water seal around the edges and simple deflectors beneath, to direct the rising gas into the collector. On this type no screen of any sort is provided to check the rising of the scum.

The formation of scum under both types of collectors has been the principal operating difficulty in collecting the gas. The screens on the Imhoff type plugged very shortly after this tank was put into operation. They were then removed.

Gas production varies greatly in unheated tanks due to the wide variation in temperature. In this climate the month of maximum production is usually September and the minimum February. The quantity of gas produced in September may be from 5 to 10 times as great as the production in February. The average production for the year 1927 was 0.406 cu. ft. per capita per day and 5.15 cu. ft. gas per lb. of volatile matter. The analysis of the gas for a period of one year gives the following figures:

Carbon-Dioxide		Oxygen		Methane		Nitrogen		B.T.U./Cu. Ft.	
Max., %	Min., %	Max., %	Min., %	Max., %	Min., %	Max., %	Min., %	Max.	Min.
26.5	8.2	0.8	0.1	84.1	64.0	18.3	2.0	848.6	650.8
A typical complete analysis being:									
14.2		0.3		74.4		11.1		750.7	

Acknowledgment.—The foregoing is taken from a paper read June 21 at the second annual meeting of the Central States Sewage Works Association and presented in the July Sewage Works Journal.

Phenol Tastes and Odors in Water Supplies of Ohio River Cities

Reduction in Intensity May Be Due to Process of Natural Biochemical Oxidation

By H. W. STREETER
Sanitary Engineer, U. S. Public Health Service

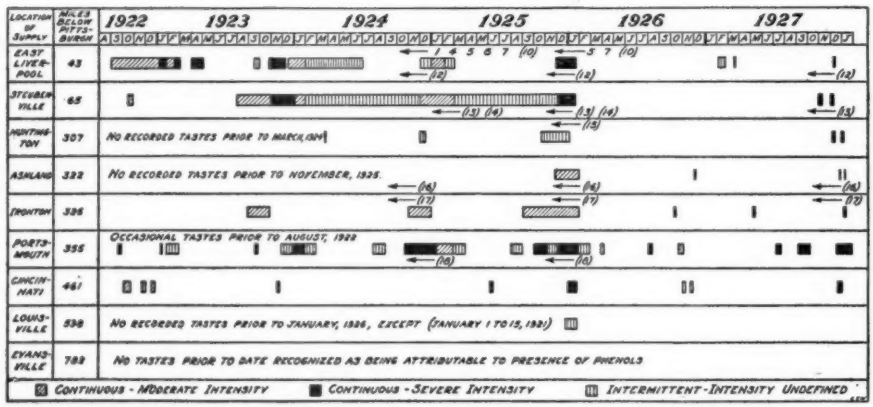
FOR several years past, and particularly since the war, tastes and odors of such a nature as to identify them with the presence of phenols and allied substances have been experienced, with varying frequencies, in the water supplies of cities located on the inland waterway systems of the middle western and easter portions of the United States. Tastes of a similar nature have appeared in water supplies located in other areas, both of this country and of Europe. In no instance, however, has this difficulty been more serious or affected larger groups of population than it has in the area adjoining and tributary to the upper portion of the Ohio River, which drains a highly industrialized region serving as a center of the coal, steel, and allied industries.

Cause of the Taste and Odors.—A search for the specific causes of the tastes and odors above described revealed that fact that during and since the war period the coke-producing industry has been abandoning the use of the older "beehive" ovens for burning coke and has been substituting for them modern by-product plants, from which valuable substances are recovered from the gases which formerly went to waste in the atmosphere. The residues from some of these recovery processes, notably those concerned with the manufacture of benzol and ammonia, have been found to contain very considerable amounts of tar, phenols, cresols, creosotes, and similar substances, which, when discharged into sources of water supplies, produce characteristic "medicinal" tastes and odors in them.[1] Although other classes of wastes, notably those derived from producer-gas plants, have been found to contain phenols and similar taste-producing substances, the total amounts of phenols resulting from the operation of coke by-product plants are so much greater than those produced by any other single industry, and their production takes place in such highly concentrated areas, that a large share of the responsibility for the difficulties caused by wastes of this class logically has been attributed to them.

Aggravated Conditions Along the Ohio River.—In the upper portion of the Ohio River Basin, and especially along the Ohio River proper, the situation has been aggravated by the fact that, in order to produce bacterially safe effluents for drinking purposes, municipal water purification plants are forced to resort to continuous chlorination of the water in addition to coagulation, sedimentation, and filtration. This condition is due primarily to the large volumes of untreated sewage that is being discharged into this river system at the present time. The addition of chlorine to water containing small amounts of taste-producing phenols has been found to intensify the tastes caused by these substances, probably owing to the formation of chloro-phenol and allied compounds which are known to have exceptional taste-producing properties.

In March, 1924, a report was prepared by Sanitary Engineer H. R. Crohurst, of the Public Health Service, giving the results of a survey which he made of the water supplies affected by tastes of phenol origin and of the industrial plants producing phenol-bearing wastes within the Ohio River Basin. In his report, 17 coke by-product plants were listed at that time as discharging wastes of this character into the Ohio and it tributaries. Later reports submitted by the departments of health of Pennsylvania, Ohio, West Virginia, and Kentucky, at a joint conference held in February, 1926, indicated that about the same number of plants as that above named were actively discharging phenol wastes at that time in this river basin.

Records of Appearance of Phenol Tastes.—Systematic records of the appearance of phenol tastes in Ohio River water supplies have been maintained, since late in the year 1921, by operators of municipal water purification plants located along the river. These records have been collected by the United States Public Health Service from time to time and brought together for comparison.


LOCATION OF SUPPLY
MILES BELOW PITTSBURGH
1922
1923
1924
1925
1926
1927
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J
EAST LIVERPOOL
43
STEUBENVILLE
65
HUNTINGTON
307
No recorded tastes prior to March, 1924
ASHLAND
322
No recorded tastes prior to November, 1925.
IRONTON
326
PORTSMOUTH
355
Occasional tastes prior to August, 1922
CINCINNATI
461
LOUISVILLE
538
No recorded tastes prior to January, 1926, except (January 1 to 15, 1921)
EVANSVILLE
789
No tastes prior to date recognized as being attributable to presence of phenols
Continuous - Moderate Intensity
Continuous - Severe Intensity
Intermittent - Intensity Undefined

Key to locations of coke by-products plants:
1. Fairmont, W. Va. 2. Clairton, Pa. 3. Johnstown, Pa. 4. Warren, Ohio. 5, 6, 7. Youngstown, Ohio. 8. Farrell, Pa. 9. Pittsburgh, Pa. 10. Midland, Pa. (11) Woodlawn, Pa. (12) Wierton, W. Va. (13) Follansbee, W. Va. (14) Benwood, W. Va. 15 Canton, Ohio. (16) Ashland, Ky. (17) Ironton, Ohio. (18) Portsmouth, Ohio. Numbers in parentheses refer to plants located directly on the Ohio River; numbers not in parentheses refer to plants located on tributaries.

Fig. 1—Graphical Record of the Appearance of Phenol Tastes in the Water Supplies of Designated Cities Located in the Ohio River, with Relative Location of Coke Byproducts Plants Discharging Phenol Waste Into the Ohio River

A comparative summary of these records, showing the period and, roughly, the relative intensities of phenol tastes observed in Ohio River water supplies, is shown graphically in Fig. 1, which has been plotted from the records thus collected. In this diagram are shown also the approximate locations, with respect to the various water intakes, of coke by-product plants discharging phenol wastes into the Ohio River and its tributaries at intervals during the period 1924 to 1927, inclusive. It will be noted in this connection that of the 17 plants indicated as discharging phenol wastes in 1924, only four were stated as remaining actual contributors in 1927.[2] The reduction was brought about as the result of joint efforts of the authorities of the Ohio River states and by manufacturers, following conferences held in 1924, 1925, and 1926. The work thus accomplished has been described so fully elsewhere[3] that it is

[1] These taste-producing substances will be designated hereafter by the single term, "phenols."

[2] In a recent paper by Waring (see reference in footnote 3), he indicates that, in the autumn of 1928, this number had been further reduced to two plants, located, respectively, at Wierton and Follansbee, W. Va.

[3] Waring, F. H.: Results Obtained in Phenolic Wastes Disposal under the Ohio River Stream Conservation Agreement. American Journal of Public Health, vol. 19, No. 7, July, 1929, pp. 758-770.

unnecessary here to discuss that phase of the subject.

On referring to Fig. 1, it will be noted that up to the end of the year 1925 tastes of phenolic orgin were present at frequent intervals and, during some periods, almost continuously, in the water supplies of East Liverpool and Steubenville, located, respectively, 43 and 65 miles downstream from Pittsburgh, and in those of Ironton and Portsmouth, located 326 and 355 miles downstream from the same point. At Ashland and Huntington, located short distances upstream from the Ironton-Portsmouth zone of the river, but about 240 miles downstream from Steubenville, the recorded tastes were considerably less both in frequency and intensity; likewise at Cincinnati, located about 106 miles downstream from Portsmouth. At Louisville, 130 miles downstream from Cincinnati, no tastes of phenolic origin were recorded until December, 1925, and January, 1926, when a wave of these tastes, of unusual intensity, extended down the river to this point.

City	Total number of months in which tastes occurred 1924-25	1926-27
East Liverpool	11	4
Steubenville	24	3
Huntington	5	2
Ashland	3	3
Ironton	7	3
Portsmouth	13	8
Cincinnati	2	4
Total	65	27

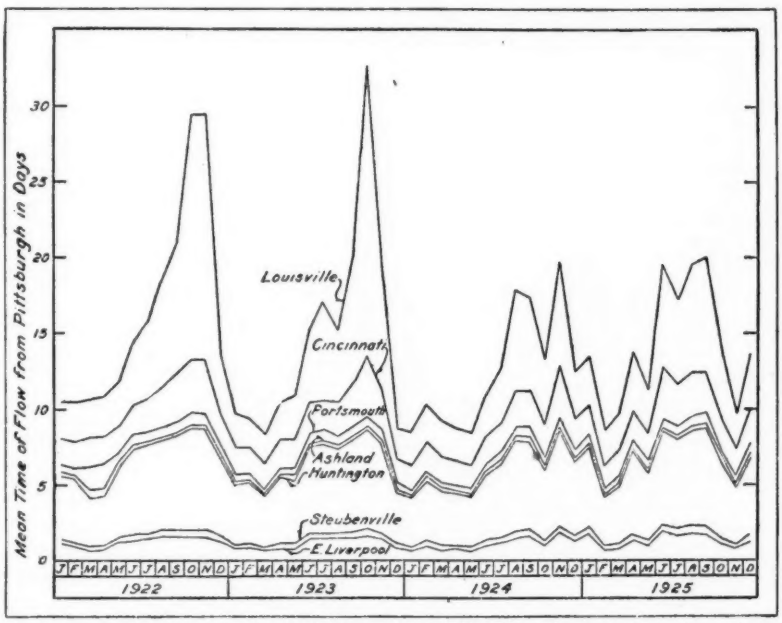


Fig. 2—Seasonal Variations in Times of Flow of the Ohio River from Pittsburgh to Designated Cities Downstream

Cooperative Control Efforts by States.—Following the December-January phenol wave of the winter of 1925-26, a renewed cooperative effort was made by the states of Pennsylvania, Ohio, West Virginia, and Kentucky to bring about the elimination of phenol-bearing wastes from the Ohio River system. The results of this effort, which left only four recognized sources of phenol pollution in the Ohio River at the end of the year 1927, were evidenced, as is shown in Fig. 1, by a well-marked diminution in the frequency and intensity of phenol tastes in Ohio River water supplies, the only outbreak of serious proportions during this period occurring in December-January of the winter of 1927-28. The change in the status of such tastes occurring after the winter of 1925-26 is further indicated by the following tabulation showing the months of the years 1924 and 1925, as compared with those of 1926 and 1927, in which tastes of phenolic origin were recorded in the water supplies of various Ohio River cities:

The figures given in the table fail to show the true contrast existing in the prevalence of tastes during the two periods indicated, because they do not take account of the greater intermittency and less intensity of such tastes during the later period. If these factors could be weighted properly, they probably would show that a reduction amounting to fully 90 or 95 per cent has taken place since the end of 1925.

Tendency to Natural Purification.—Aside from the foregoing indications, the conditions illustrated in Fig. 1 are of considerable scientific interest in that they afford fairly definite evidence that the concentration of taste-producing phenols in the river has had a marked tendency to become reduced progressively, in passing down stream, to a greater extent than can be accounted for by increased dilution or by any other wholly physical influence. The evidence at hand suggests very strongly, in fact, that a large part of the reduction observed is due to some natural process of purification, similar in its general mode of action to other phenomena commonly associated with the self-purification of streams.

The tendency above noted is indicated, broadly, (a) by the sharp reduction in the prevalence of phenol tastes observed in water supplies located at considerable distances down stream from sources of phenol pollution, as compared with their prevalence in supplies located in the more immediate vicinity of such sources of pollution, and (b) by the marked seasonal variations in the relative frequency and intensity of phenol tastes occurring in all of the Ohio River water supplies and especially in those further removed from sources of phenol pollution.

On referring to Fig. 1 it will be noted that during concurrent periods phenol tastes occurred less frequently at Huntington, Ashland, Cincinnati, and Louisville, all of which were located at distances of more than 100 miles downstream from recognized sources of phenol pollution, than at East Liverpool, Steubenville, Ironton, and Portsmouth, which were located within short distances of such sources of pollution. The reduction observed has been particularly striking between Steubenville and Huntington, a distance of 242 miles, and between Portsmouth and Cincinnati, a distance of 106 miles. In the latter instance the reduction in the frequency of phenol taste prevalence, amounting to over 80 per cent, occurred in a river stretch in which the total amount of dilution water added to the Ohio, mainly through the Scioto River at Portsmouth, ordinarily is less than 10 per cent. In the former case, it likewise could be shown that the reduction experienced in the prevalence of phenol tastes was far greater than would be accounted for in terms of added dilution water.

It further will be noted in Fig. 1 that although phenol taste-producing substances penetrated throughout the Ohio River as far as Cincinnati on several occasions during the winter and early spring, they did not appear during the summer or early autumn at any of the cities removed by any considerable river distance from points at which phenol wastes were discharged into the river. If dilution were a dominating factor in these variations, their trend would be expected to be exactly the opposite of that actually observed, since the maximum flow of the Ohio River occurs in the winter and early spring.

Although no data are at hand concerning the seasonal trend of production of phenolic wastes by coke by-product plants, it hardly would appear, from the nature of the industry, that such wastes could be produced in sufficiently greater volumes during the winter-spring season, as compared with the summer-autumn period, to account for the wide seasonal variations above noted.

The condition shown in Fig. 1 is entirely consistent, on the other hand, with the view that the seasonal and

geographic changes in phenol tastes prevalent observed in the various Ohio River water supplies have resulted largely from some natural process of purification which, though limited in its action, like all other processes of stream self-purification, is sufficiently powerful to bring about a marked progressive reduction in the density of phenols in stretches of the river relatively free from increments of pollution of this character. Thus, it is noted that the maximum reduction has occurred during the summer and early autumn seasons when the Ohio River usually reaches its lower stages, and the effect of longer times of flow, as illustrated in Fig. 2, is accentuated by that of higher stream temperatures. In general, the period in which evidences of phenol pollution, as gauged by the appearance of tastes in water supplies, have penetrated to the downstream points far removed from the sources of such pollution, have occurred coincidentally with shortened times of flow, as indicated in Fig. 2, and with relatively low stream temperatures, both of which conditions tend, in general, to bring about reduced natural purification effects in streams.[4]

Progressive Reduction May Be Due to Natural Biochemical Oxidation.—In the foregoing connection reference may be made to recent studies by Mohlman[5] and his associates, which have shown that the oxidation of phenols, which can be accomplished by ordinary biological processes of sewage treatment when phenolic wastes are mixed in proper proportions with sewage, is essentially a biochemical phenomenon, proceeding along definite time-function curves at rates varying closely with the temperature, being greater at higher temperatures, and vice versa. As the behavior of phenols in the Ohio River has been consistent, except in degree, with their reactions to artificial processes of oxidation, it would seem quite logical to infer that the progressive reductions thus observed under natural conditions may be due to a process of natural biochemical oxidation similar, in its general characteristics, to that which proceeds more intesively under artificial conditions.

If the foregoing theory is correct, its lesson is fairly obvious in so far as its application to problems involving the elimination of sources of phenol pollution of water supplies is concerned. In cases in which water supplies are subject to continuous or frequent pollution by phenols, the important sources of such pollution are more likely to be found in the near vicinity of the supply than at any considerable distance. If, however, they are subject only to occasional pollution, occurring more especially during the colder season or, in streams, coincidently with high river stages, the source of the trouble probably is located at a more distant point. In undertaking any general program of remedial measures looking to the relief of phenol pollution of water supplies, located along an entire stream, the maximum immediate benefit of such measures probably will be attained by eliminating, first, all sources of phenol pollution located directly on the stream in question or in the lower reaches of tributaries discharging into the main stream above the points at which the water supplies affected are located. The history of phenol tastes in Ohio River water supplies, both during and following the institution of progressive remedial measures by the bordering states, has afforded an interesting confirmation of the principle stated, as is indicated in Fig. 1.

The effectiveness with which the pollution of Ohio River water supplies by phenol wastes has been brought under a large measure of control within the comparatively short period of time intervening since the year 1925, constitutes one of the brightest pages in recent sanitary history. Accomplished, as it has been, without any coercive legislation, but through cooperative effort by the federal and state governments and the industries concerned, it augurs well for the future solution of some of the larger problems of stream pollution now confronting the nation. Although pollution of the Ohio River system by phenol wastes has not been completely eliminated, as evidenced by occasional "spills" which have occurred during the past year or two, it has been curbed to an extent such as to justify the expectation that in the near future it will cease to be a major problem along this important waterway. A generous measure of credit is due to those whose joint efforts have brought about this fortunate result.

Acknowledgment.—The above article is taken from the Sept. 6 issue of Public Health Reports. It is based on a discussion contributed to a symposium on phenol pollution, held at the annual meeting of the American Public Health Association, Chicago, Ill., October, 1928.

[4]See Public Health Bulletin No. 143, pp. 298-335; Public Health Bulletin No. 171, pp. 179-199; Public Health Reports, Reprint No. 1063, pp. 31 and 45; also Reprint No. 1232, pp. 9-13.

[5]Mohlman, F. W.: The Biochemical Oxidation of Phenolic Wastes. Am. Jour. of Pub. Health, Vol. 19, No. 2, February, 1929, pp. 145-154.

The Importance of Controlling the Raw Water

By A. L. GOSNELL
Filtration Plant Operator, Laurel, Md.

In presenting this article it is the writer's intention to bring out the importance of controlling the raw water where it is possible to do so.

The filtration plant at Laurel, Md., has a capacity of 500,000 gal. per day. The lake, or raw water reservoir, has a capacity of 7,000,000 gal. and is situated about a mile and a half from the plant. The stream entering the lake is derived from springs, and has a flow of about 500,000 gal. per day. This water, under favorable conditions, is exceptionally easy to control, yet under unfavorable conditions control borders on impossibility. The detention period in the lake is 14 days. The lake was made more than thirty years ago and the weeds, grass and bushes have been permitted to run wild, with the result that a favorable medium for algae growths has been produced.

It is customary to use copper sulphate to control algae growths, but we have learned that when trouble exists, the proper thing to do is to find the cause and remove it. Of course the proper thing to do in this case would be to clean up the filth and remove the weeds and grass around the lake. Cleanliness is of much importance even in the raw water. However, when the necessary cleaning is not done, it is necessary for the operator to take other steps. Past records revealed that during the winter months the pH of the water is about 7.0 and that from June to December it is about 6.0. It was the opinion of the writer that if the pH of the raw water could be held near 7.0, the carbonic acid would be eliminated, thereby cutting off the food supply of the growths and retarding their development.

In June, 1928, conditions were bad. A turbidity of 80 required an alum dosage of 1 g.p.g. for treatment. In an attempt to improve conditions, the lake was treated with hydrated lime. One hundred pounds of lime was spread around the entire circumference of the lake, extending about 5 or 6 ft. out from the shore. One bag of lime was tied up in a canvas bag with a few holes punched in it and anchored in the stream about 100 ft. above the inlet to the lake. The bag of lime was renewed every month from June to December.

The effect of the lime was noticeable almost immediately. A concrete dam that had formerly been covered with a slippery scum became clean and safe to walk on within a few days, the dose of coagulant was cut in two and the water was very easy to control. The treatment had only one objectionable effect: the oxygen content was increased to such an extent that the filters became air-bound in a 2½ to 3-hour run. However, this slight objection was overbalanced many times by the improved condition of the water. About 12 months were required to come to a decision as to the effect of the lime treatment. From July 4 to July 22 of this year the average turbidity was 150, with a maximum of 300, and at no time during that period did the alum dosage exceed ¾ g.p.g. This is in strong contrast to the dosage of a year ago, when a turbidity of 80 required 1 g.p.g.

Unusual Features of Filter Plant Design

Special Arrangements for Proposed Plant of Niagara Falls, Ont.

By F. A. DALLYN
Consulting Engineer, Toronto, Ont.

AS a preamble to this paper, I must state that the plant to which my remarks relate has not as yet been built. The design has been complete for something more than a year, and tenders were invited for the building in the spring of this year; but owing to misunderstandings and political and other controversies, the work has not yet gotten under way.

The Supply.—At Niagara Falls we have a Great Lakes water, taken from one of the connecting rivers at a point of high velocity—a water subject to some pollution, never very intense, and subject to turbidities which might be common also to such plants as Cleveland, Erie and Buffalo.

Lake Erie is a relatively shallow lake and storms promote a continuing turbidity, which sometimes exists for a week at a stretch. Ordinarily the water is fairly clear, possessing sufficient alkalinity to react with the aluminum salts without occasioning any aftermath of red water difficulties. The velocity of the river suggests that some difficulty might be encountered from frazil ice.

Construction Features.—The site selected for the location of the plant was a point on Dufferin Island, where the ground elevation was some 14 ft. to 15 ft. below the mean water level of the forebay of the Ontario Power Co., and the elevation of the rock formation which forms the base of the reservoir was discovered some 14 ft. below ground elevation— i. e., about the ideal position for foundations.

The site itself is part of the Niagara Falls Park system, and is heavily covered with vegetation, but accessible by road and by electric railway. The size of the plant, approximately 5,500 cu. yd. of concrete, suggested that a central mixing plant would be an economical arrangement, and the elevation of the approach suggested that material brought in on the electric railway could be dropped into bins and mixers without secondary handling. By an understanding with the Victoria Parks Commission, it was agreed to limit the destruction of trees to an area 75 ft. around the limits of the proposed works, and the problem of the contractor was to utilize this ground to such advantage as to permit him to carry on the works expeditiously without any further destruction of vegetation.

The contractors bidding on the work saw no particular difficulty in the arrangement, except that if the electric railway was not utilized there might be some embarrassment experienced, owing to the park superintendent limiting loading capacity of trucks and vehicles for the purpose of preserving and maintaining, during the tourist season, the river boulevard property, which also serves as approach to the plant.

The site naturally suggested a gravity plant with the high-duty pumps arranged so as to draw directly from the level of the clear-water reservoirs.

Mixing Chemicals.—The use of the hydraulic pump was considered and approved for the purpose of mixing chemicals, water being admitted from the upper forebay to the rising well and controlled by a mechanism actuating through floats and controlling the hydraulic inlet valve. After passing over the hydraulic pump, the water passes through the usual type of sedimentation tank and flows directly on to the filters through ports controlled by sluice gates, the wash-water channel and troughs being utilized for both the admission of sedimented water and the withdrawal of wash water.

Pipe Gallery.—The first unusual feature is perhaps the pipe gallery, with its arrangement whereby a travelling crane can be installed, hung from the upper beams, for the purpose of erecting and handling the control parts and pipes. The use of victaulic couplings rather than the flanged connections was contemplated, and in my opinion, offers considerable advantage.

Sand Strainers for Underdrain Systems.—The second unusual feature is the sand strainers for the underdrain system. Instead of making use of any of a group of patented arrangements, either of sand valves or special grids, I have recommended the use of a cast iron cover over a concrete trough, with a simple design of manifold cast integrally with the cover. This in itself is not unknown, having been used at St. Catharines. The unusual feature is that instead of screwed or leaded joints I propose to use a tapered push joint for the radial 1½-in. or 2-in. pipes, and hold them in place with a concrete haunch along the base of the tank. The arrangement has several very important advantages. It is incapable of a leakage greater than that from any one of the openings, and it is incapable of breaking away from the main header, as has been the case in some of the screwed pipes or leaded joints. It also appears to be a most economical arrangement.

Chemical Storage.—The next feature of interest has to do with the storage of chemicals. The plant which I was designing was to be such that it could be operated by the existing personnel, with the occasional inclusion of ordinary labor for special purposes. For this reason, instead of using overhead storage and dry feed machines, as is most convenient and satisfactory in a lot of plants, I used a portion of the foundations for wet storage of a saturated solution and capable of receiving several cars of chemicals. The chemical is taken from the cars and discharged down a manhole to a lower bin, which is immersed in water. When the storage is first charged, a portion of the chute will be full of undissolved chemical and will remain so until the use of chemical will have dissolved out the portion supporting the overlying mass. It was my intention to pump the concentrated chemical to a solution feed machine actuating from a constant level, diluting the solution as the reactions intimated was advisable.

In addition to alum storage, I purposed having track-work suspended from the ceiling of the screen room, so that I could use drums of ferric chloride, either to supplement the alum or to displace it entirely during periods when the ferric chloride might be suggested as the more suitable chemical.

Arrangement of Screens.—In the screen room, while it is not an unusual feature, the arrangement is specially adapted to the removal of frazil ice, and the screens themselves are of the sloping rather than the vertical type, so that they can be elevated out of the water, should conditions be acute. After passing the screens, the water flows directly over the pump and through the settling tank, and then on to the filters. Instead of using earth on top of the settling tanks, I thought it advisable to insulate them with cork, or other suitable material. According to the estimates, the difference in cost was not prohibitive, and it had a great many advantages which determined our policy in the matter. The entire roof of the building is also insulated, to keep down condensation and to simplify heating problems.

In the pumping station we have venturi controls both on the inlet water and on the water going to the suction well for the pumps. These controls are primarily for the proper application of chemicals. They also actuate the mechanisms which regulate the opening of the hydraulic valves, maintaining constant differential levels.

Piping Layout in the Pumping Station.—The piping layout in the pumping station is somwhat unusual in that provision is made for testing any of the several units in use, without throwing the station or other units out of service. The units have both duplicate discharge and duplicate suction lines, as recommended and urged by the underwriters. A by-pass has been introduced, so as to relieve the discharge system into the suction well for testing purposes.

The arrangement for the supplying of power for the operation of the electrical pumps is rather unique, although not novel to this plant, in that it provides an inter-switching arrangement with four of the principal developing companies at Niagara Falls, and precludes the possibility of any shutdown of duration.

It was my intention, in connection with the service pumps, to have push-

button control on the electric circuits and a hydraulic or electric valve operating the discharge line; the whole arrangement both of the filter plant and of the pumping station being such that the operators had a minimum amount of manual labor, and such appliances accessible as would permit the keeping of the staff down to the irreducible minimum.

Acknowledgment.—The above is an abstract of a paper presented at the Toronto convention of the American Water Works Association.

Financial Aspects of Municipal Water Works

Some Details That Make for Successful Operation

By C. A. McCLAIN
General Superintendent-Secretary, Water Board, Eugene, Ore.

AN essential foundation for the successful operation of a municipally owned utility is the proper attitude on the part of the citizens. They must be willing to adopt a charter so drawn as to admit of business-like conduct of the utilities without undue obstruction or hampering through formality and red-tape.

The Management.—The management should be in the hands of a commission stable in its organization, nonpartisan, independent in its action and separate from other departments of the city, whose members have no other city offices. They will thereby be free to make decisions and formulate policies for the best interests of the utilities and will be nonpartisan and uninfluenced by other city interests.

The management of the utility should be put on a sound and dignified business basis which will not give the citizens the impression that the utility is a plaything which may be used to meet the passing whims of various groups or organizations. The term of office of the members should be long enough to enable them to become really familiar with the problems involved and terms should so terminate as to bring one or at most two members on the board at the same time.

The Employees.—The financial status of any business whether a utility or a commercial enterprise is determined very largely by the organization or staff of employees. The same principles apply to this kind of organization as are effective in any other kind of business. They must be loyal, industrious and efficient, and their salaries should be as much as the same people would be paid anywhere else for doing the same kind of work. A city employee should not be expected to work for less than he could get elsewhere, and it is demoralizing for him to be required to apologize for his salary.

The service furnished by a municipal utility may be up to the standard of a privately owned utility if the ordinary rules of conducting such businesses are observed and if efficiency, initiative, loyalty and other desirable characteristics of employees are recognized and rewarded.

The Rates.—Rates should be as equitable as possible and should provide for the payment to the utility by the governing board of adequate rates for all service furnished for public uses, such as street flushing, sewer flushing, fire protection, street lighting and other service furnished for the general public. They should be sufficient for all legitimate requirements such as operation, maintenance, interest on bonds, sinking fund for retirement of same, an emergency fund, taxes if paid by the utility, and should also provide a substantial surplus for minor extensions for plant.

Taxation.—Municipally owned utilities are exempt from taxation in most states, although in some states a bookkeeping entry is required to show the status of the utility as if taxes were paid. Some utilities make a voluntary payment to the governing body of the city, while on other occasions the governing body exacts the equivalent of taxes or in some cases much more through its demands for free service. Practically all economists hold that municipal utilities should pay taxes the same as are paid by privately owned utilities, although some propose that all utilities be exempt because of the fact that the consumer must in all cases pay the tax.

If taxation is applied equally to all municipally owned utilities there may be no objection to this, although the legal requirement that all cities provide a sinking fund for the retirement of bonds in addition to all other requirements of operation and maintenance impose an additional burden on the municipal utilities which privately owned utilities do not have to carry and it would seem fair that the municipal utilities may be entitled to tax exemption because of this sinking fund requirement.

Financing New Developments.—In the case of new developments the capital required must of necessity be borrowed. The usual way of acquiring that capital is through the issuance of bonds. If these are general obligation bonds they usually carry a lower interest rate than that earned by securities on privately owned utilities although the sinking fund requirement mentioned above may entirely offset this advantage. In some states utility bonds are issued, that is, bonds secured by the utility itself, in which case the interest rate is about as high as that paid by privately owned utilities, and may even exceed that rate.

Securities Owned by Local Citizens.—The customer ownership plan which is coming into general use with privately owned utilities, is excellent, and it would be a decided advantage if the municipally owned utilities might avail themselves of this plan in the distribution of bonds directly to its own citizens. If this were possible the municipal utility could well afford to pay a higher interest rate than when its securities are owned by people not directly interested in the service. A substantial emergency fund should be provided, the size depending on the general type of utility and also on the individual utility as to its own hazards. It is not practicable to issue bonds for the construction of every small extension required for service and therefore it seems a good policy to provide for most of the small extensions and a fair percentage of the larger ones from earnings from the system after it is in operation. If this be done, the ultimate effect will be lower rates because of the reduced charges on account of being relieved of interest and sinking fund requirements. Corresponding rate reductions will in effect be a division of this surplus with the customer.

Long time budgeting is equivalent to long distance planning, and will keep the utility prepared to meet future demands and at the same time will enable it to appropriate to specific projects net income accruing from year to year as a result of operations. This can be done only through a constructive expansion program which must be carried out without interference.

Accounting.—Accounting is an extremely important phase of the management of the municipally owned utility and should be in the hands of a competent staff of accountants. Above all the commission and its manager should not fool themselves regarding the exact financial status of the utility. Although not required by the Oregon laws to do so, we believe that it is to the best interest of the utility to use the Uniform System of Accounts prescribed by the Public Service Commission.

No department can be any better than its personnel. Therefore, the commission should avail itself of the specialists available, in the conduct of its business and in the meeting of new problems incident to its expansion program. A few of these experts who are readily available and who can be of great value are auditors, consulting engineers, economists, financial authorities, geologists, lawyers, rate engineers and testing engineers. As occasion may arise for the knowledge of these specialists, their employment will be found one of the best investments the utility can make.

Acknowledgment. — The foregoing paper was presented at the recent municipal finance conference held at the University of Oregon, in cooperation with the League of Oregon Cities.

Testing Cast Iron Pipe

Apparatus Used and Methods Employed

By WILLIAM R. CONARD
Conard & Buzby, Burlington, N. J.

THE apparatus used for testing primarily consists of a hydraulic press; the machines for the physical testing of the metal; and the tools (caliper, gauges, hammer, etc.), which the inspector uses in connection with the visual examination of the pipe. The hydraulic press is a piece of apparatus which seals each end of the pipe, fills it with water, exhausts the air, and then by a pump acting usually through an accumulator raises the water pressure in the pipe to some specified amount. The other apparatus for physical testing of the metal usually consists of a tensile and transverse testing machines in which prepared pieces of iron, usually called test bars, are subjected to tensile and transverse stresses to determine strength and resiliency. The inspector's tools are his pick hammer, caliper for measuring the thickness of the metal and other dimensions, and gauges to further calibrate the different dimensions of the pipe and fittings.

Methods Employed.—After the pipes are cleaned and chipped and have undergone examination on the skids for dimensions, quality and appearance, they are put under hydraulic pressure and tested for strength and porosity. This is called in the specifications the "hydrostatic" test. There was a time in pipe making when this test was applied in an adequate manner to all sizes, as it still is in the case of larger pipe; the present practice in testing pipe 3 in. to 20 in., however, can only be termed adequate if the specified pressure applied for as short a time as 10 seconds is considered satisfactory. The reason why the pressure is held for such a short period of time is that the facilities for this part of the operation of producing pipe has in most cases been lost sight of in the endeavor to keep up to quantity production, and the necessary room and apparatus for the testing have not been provided for by the manufacturer to the same extent as have the facilities for the other manufacturing operations. On the importance which the purchaser attaches to the hydraulic test, would therefore depend the period of time to be specified that the pipes are to be held under pressure before they are accepted.

The apparatus for demonstrating the physical properties of the iron are usually the standard tensile and transverse testing machines fitted up to take the type of test piece which the specifications call for. The pieces for the tensile tests have approximately a 1 sq. in. cross sectional area, and for the transverse area 2 in. by 1 in. by 26 in.

The inspector's tools are primarily the pick hammer with which the pipes are tried for hardness and indications of and visible defects are explored; the caliper, which is used to measure the thickness of metal, and sometimes other dimensions, and gauges for checking dimensions. Other tools are measurement rules, steel tapes and minor special or odd tools used at intervals as a check.

Some purchasers require a check on the chemical components, and where this is required, the inspector has to have sufficient knowledge of irons to know something of the grades by visual examination, and to tell whether the proportions are right when the foundry analysis is made.

One of the most important functions of a proper testing of cast iron pipe is the inspector's visual examination of the individual pipe, and to be able to perform this part of his work properly requires that he have a good working knowledge of molding, pattern making, machine shop practice, chemistry and, most important of all, the causes and effect of the things that can and do happen in the manufacture of the pipe. Also, and of considerable importance, a knowledge of the principles of engineering as applied to the uses to which the pipe are to be put. All of these, together with good common sense and sound judgment, enables the inspector when he examines a pipe or special to quickly determine the suitability of that particular pipe or special for the use for which it is intended.

Other duties connected with the inspection or testing are for the inspector to witness the tension and transverse tests, to determine the general physical properties of the iron, maintaining a check on the producing the test pieces for these tests as well as the chemical analysis, and to maintain supervision over the coating as well as the weighing. Many purchasers also keep the inspector informed as to their requirements on delivery so that he being directly on the ground sees that these requirements are adhered to.

One of the last tests of pipe before loading for shipment is to weigh the individual pipe or casting to see that it comes within the limits for its size and class; if it is too light, it is either placed in a lighter class or put among the culls, and if too heavy it is either marked down to the top limit, placed with a heavier class, put in the culls, or if too far out of the way it may be scrapped.

Summary.—It is difficult to describe by written word the details of the testing of cast iron pipe, and to describe the methods used, for there are as many as seventy odd things that may make a pipe unfit for use, and therefore the individual visual examination is a most important part of the testing, and much depends on the extent of the training and the experience of the inspector, and his attitude toward his work. If he has had the training, is interested in what he is doing and why he is doing it, and assumes an unprejudiced attitude to both the material and those producing it, and also is willing to place himself in the position of trying to learn something each day, the purchaser who is having the material tested by such an inspector can usually rest easy and feel pretty well assured that his interests are being properly looked after. It is to be conceded that unless the work of inspection of pipe and castings is honestly and intelligently performed that the purchaser is spending money uselessly.

Acknowledgment.—The foregoing is an abstract of a paper presented Sept. 19 at the 48th annual convention of the New England Water Works Association.

Cost Accounting for Sewage Works

The System of Urbana-Champaign Sanitary District

By GUS H. RADEBAUGH
Manager, Urbana-Champaign (Illinois) Sanitary District

RECORDS of costs of operation of sewage treatment works are of vital importance, in my opinion, with regard to the successful future of the subject in which we are so much interested.

It is not my desire in this short paper to present methods of cost accounting than can be used and adopted in the management of all treatment works. I do appreciate, however, that the engineering profession and the industries associated with this problem will be penalized by a public which is desirous of clean streams, better health and a keener respect for the great out-of-doors, if this group and similar organizations neglect the importance of a standardized national code of cost accounting for the construction and operation of sewage treatment works.

It is my opinion that community progress comes only to those municipalities which are fortunate enough to accept correct and economical design of public works, and which have public leaders who believe in and see to the intelligent expenditures of public monies. This and similar associations can do much to encourage and assist in establishing correct standards for our community leaders to follow.

Many of the citizens of the State of Illinois have awakened to their individual responsibility with relation to the pollution and destruction of the state's beautiful rivers, and are accepting the challenge of civilization by proper disposal of sewage and industrial wastes. Illinois has 22 sanitary districts organized under the Law of 1917 and 2 districts organized under special acts, the

Chicago and North Shore Districts. It is established that 135 cities and towns in the state are recognizing in some manner the importance of treating their waste.

The Urbana—Champaign District.—The Urbana and Champaign Sanitary District, organized May 24, 1921, was the fifth municipality in the state to take advantage of the Law of 1917. This district consists of a rectangular area with a maximum width of 2.5 miles and a length of 4.0 miles. The total area within the Sanitary District is 5456 acres or 8.53 square miles. The total population is now 38,540. The density of population for the district in 1930 is estimated at 6.4 per acre; by 1960 this may increase to 12.8 per acre. The present assessed valuation is $27,150,053. A $500,000 bond issue was voted Nov. 28, 1922. The total sewage treated the past four years is approximately 5,346,000,000 gal. an average of 1,336,525,000 gals. per year, or 3.66 million gallons per day.

A complete report covering operation and management of the district's affairs has been published annually, giving to the tax payers a financial history of the operation of their project. A yearly audit is made of the income and expenditures by a public accountant.

Essentials of Cost Accounting system.—In designing the cost accounting system used by this district several standards were established as essentials in maintaining an accurate record. These essentials were:

1—Any system used should be substantiated by the budget method of financial control.

2—The system used should make possible without excess labor a monthly operating balance sheet.

3—All expenditures should be properly charged to accounts as established by the tax levy ordinance.

4—The tax levy ordinance should be divided into specific accounts and amounts—thus

B-2 Employee's wages, $00.00.
B-3 Power and coal, $00.00.
B-4 Water, $00.00.
B-8 Grounds, $00.00.

5—Voucher checks must be signed by two officers of the Board and the Treasurer.

6—No account should be paid unless an itemized invoice is issued to the District covering the item of expense.

7—A yearly certificate of audit must be received by the Board from a public accountant.

With the above essential as the guide, the following is the adopted accounting program:

The Accounting Program.—The Treasurer of the District, under $50,000 bond, receives the monies collected from the levy by the County Treasurer and deposits same in the District's depository. The Treasurer makes a monthly report to the trustees of receipts and expenditures.

The manager receives the invoices for payment, arranging them into the proper accounts as established by the tax levy. They are then presented to the board at a regular meeting for approval or rejection. When the approval is made and the authorization is made a part of the minutes of the board meeting, a voucher check is drawn in favor of the invoice, the number of the check being entered on the invoice, it then being filed for audit. The check is signed by the President and Clerk of the Board and by the Treasurer. The Treasurer makes the entry in a distributional ledger. The manager enters the paid accounts under the proper distribution. The manager also presents to the Board a monthly appropriation analysis or budget control sheet, which shows at a glance the working balance of the various accounts, expenditures this month, expenditures to date, appropriation unexpended, total account balances and the bank balances for the month. This monthly appropriation analysis has been found to be of paramount importance in the proper control of all expenditures. The accounts of this district have the following headings:

For Interest and Bonded Indebtedness

A-1	Interest due and payable June 1, 1929	$00.00
A-2	Interest due and payable Dec. 1, 1929	$00.00
A-3	Principal payment due and payable Dec. 1, 1929	$00.00

For Other Corporate Purposes

B- 1	Salary of Ofc. & Atty. Fees	$00.00
B- 2	Employee's Wages	00.00
B- 3	Electric Power & Coal	00.00
B- 4	Water	00.00
B- 5	Repairs on Equipment	00.00
B- 6	Supplies & New Equip.	00.00
B- 7	Lab. & Ofc. Exp.	00.00
B- 8	Ground Maintenance	00.00
B- 9	Secondary Sett. Tank	00.00
B-10	Contingencies	00.00

Cost Data.—The district published reports show the following cost data:

Costs Per Capita

	1925-26	1926-27	1927-28	1928-29
Operation	$0.42	$0.48	$0.35	$0.38
Total	1.74	1.62	1.54	1.53

These figures represent all expenditures passed for payment by the Board of Trustees such as bond interest, bond retirement, new construction, engineering fees, legal costs, plant operation labor, etc., in fact every expenditure incurred by the district.

Conclusions.—The general public demands correct and standardized cost accounting for sewage treatment works.

In the opinion of many engineers cost comparison of works operation is at the present time difficult due to the varieties of interpretation of operation costs.

The strongest force tending to stimulate construction of sewage treatment works is the intelligent and honest management of those already in operation.

In my opinion the Izaak Walton League of America and the American Public Health Association have done more to prepare the public for the acceptance of correct sanitation than all other agencies combined.

With the above conclusions as my forerunner, I respectfully present to this convention this recommendation:

"That this organization recommend to the officials of the Federation of Sewage Works Associations that a national committee be developed to standardize a national code of cost accounting adaptable for sewage treatment works operation."

Acknowledgment.—The above is a paper presented June 21 at second annual meeting of the Central States Sewage Works Association, and printed in the July Sewage Works Journal.

State Sanitary Engineers Hold Phenol Conference

W. L. Stevenson, chief engineer of the Pennsylvania Department of Health, and E. S. Tisdale, chief engineer of the West Virginia Department of Health, met Ohio's chief engineer at East Liverpool, Ohio, July 9, on an important conference following which several joint inspections were made, "Ohio Health News" states.

The city of East Liverpool has provided new devices which are in the experimental stage and with which it is hoped to demonstrate the feasibility of minimizing, if not eliminating, bad tastes in Ohio River water resulting from accidental discharges of phenolic materials from by-product coke and other works where such wastes are being treated. This effort on the part of East Liverpool is a follow-up of work done in cooperation with the health department engineers of the other states in the Ohio River interstate stream conservation agreement. Practically all by-product coke works in the Ohio River drainage area have provided complete treatment devices for eliminating phenol, these devices being of varying types. However, it has been recognized that occasionally there may be accidents resulting in spills of the wastes for a few hours, which might occur a few times during the year.

In order to cope with this situation studies have been under way, chiefly at the Ohio Department of Health laboratories, in the way of research upon ways and means to combat the phenol at the water purification plants. One of the processes, demonstrated at the East Liverpool water purification plant, consists of superchlorination with chlorine gas and dechlorination with sulphur dioxide gas. The meeting at East Liverpool perfected notification arrangements whereby prompt notice would be available to the East Liverpool chemist and others downstream so that steps could be taken in the effort to eliminate the phenolic tastes from spills. The East Liverpool meeting was also attended by the district engineer of the Pennsylvania Health Department located at Pittsburgh. City officials present were: service director, A. W. Moore; water works clerk, F. K. Robinson and city chemist, T. H. Larkins.

Testing Large Meters in the Field

Methods with Freeman Nozzles and with Previously Calibrated Meters

By R. E. FERGUSON

Assistant Superintendent, Hersey Manufacturing Co., South Boston, Mass.

TESTING by the use of the Freeman nozzle is mostly confined to laboratories of insurance companies, pump manufacturing companies and universities. If one has an unlimited flow of water, there are many advantages of the nozzle test over the tank and scale tests. For instance, the range of flow is easily controlled, the duration of the test is not confined to a few hundred cubic feet, and if the tests are conducted in a careful manner, they are very accurate.

Testing with Freeman Nozzle.—Figure 1 shows an 8 in. meter in a nozzle-testing machine at the Lowell Water Department, Lowell, Mass. As this is a 6 in. machine, and we wanted to test an 8 in. meter, we used on the inlet end of the supply a 6 in. x 8 in. adaptor and about 12 ft. of 8 in. straight pipe. On the outlet end of the meter, we used an 8 in. x 6 in. adaptor, the control valves and about 8 ft. of straight 6 in. pipe, with the pizometer and nozzle on the end. This straight piece of pipe ahead of the pizometer was sufficient to straighten out all the eddies and current induced by the change in pipe sizes. The pressure in the pizometer was regulated by the three valves, 6 in., 2 in. and 1 in. In running a test, we opened the larger valve until the pressure was within about ½ lb. of that desired, and then we used the small valve for the finer adjustments. With this small valve, we could also control any slight fluctuation of the pressure. During the test, the pressure was checked in two ways. First, by the spring gauge which was attached to the pizometer, and secondly, by the mercury column which was also attached to the pizometer, through the same connections as the spring gauge. The spring gauge is graduated in 1/10 of a pound, and the mercury column in 1/5 of a pound. On this test we used the 1 in. and 4 in. nozzles. The rates varied from 75 g.p.m. to 2,880 g.p.m. The pressure at the nozzle used was from a minimum of 6 lb. to a maximum of 29 lb. The pressure on the inlet side of the supply line was 70 lb.

Figure 2 shows a close-up of the meter and a mercury column to check the loss of pressure across the meter and the method of attaching the mercury column to the meter. It also gives a better view of the flow regulating valves. I might also add that on the inlet end of the supply pipe, an air release valve was installed. The water was supplied through about 40 ft. of 6 in. pipe to the test machine and was a take-off from a 24 in. main. The water was discharged into the pump well so there was no waste of water.

Method with Previously Calibrated Meters.—Figure 3 shows an installation of a 4 in. compound with a 4 in. bypass and the proper valves installed so that the meter repair man can test and repair the meter without interference with the consumer's water supply.

In some cities, these bypasses are the same size as the meter. That is to say, if there is a 4 in. supply line, the bypass around the meter is a 4 in. This bypass flow is controlled with a gate valve which is locked tight with a chain and padlock, the only key to which is held by the water department, and in some cases, seals are used. In this picture, you can see the test meter attached direct to the meter with a 2½ in. hose. In some cases, a test tee is installed in the line between the outlet end of the meter and the gate valve. This installation, as you can see, has a 2 in. gate valve attached to the meter below the hose connections, the advantage of this being that when making a test, the valve on the inlet side of the meter does not have to be shut to make test connections. If it is necessary to shut down the valve to make test connections, the incrustation from the side of the valve may be broken and lodged in the meter stopping same. This would necessitate opening the meter and cleaning it out before conducting a test, which in the case of a disputed bill would make the test almost worthless.

The illustration also shows the meters which we have used a good many years for making this test—a 3 in. velocity meter for the large flows, and a ¾ in. disc meter for the small flows. These two meters are connected to the meter to be tested with a 2½ in. high pressure hose, the flows through the 3 in. meter being controlled by a 3 in. quick-closing valve, and the flows through the small meter being controlled by the ¾ in. angle valve on the side of the 3 in. meter to which is attached the ¾ in. When using the small meter, the 3 in. gate is closed, and vice versa. The 3 in. valve is a quick-closing valve which enables the tester to close the meter more accurately than by a screw stem valve. The rate of flow is controlled by only partially opening the quick-opening valve, and, with a little experience, the tester can gauge his flows very close to the desired rates. Of course, he checks his flows with a stop-watch. In some cities, different sized orifices are used to control the rate of flow, but of course, as the pres-

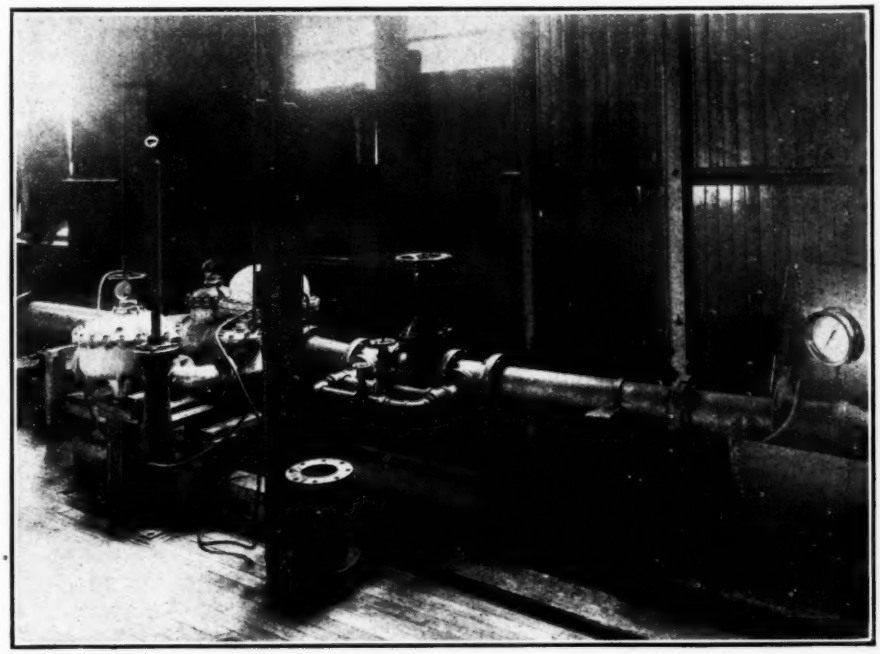


Fig. 1—Installation of 8 In. Meter in the Freeman Nozzle Testing Machine

sure varies in different localities, so will the rate of flow.

In some cities, where they test their large meters at least once a year, the engineer in charge runs what he calls an up and down test. This is run by opening and closing the controlling valve, slowly, during the test so that during the test the flow will vary from the minimum to the maximum rate of the test meter. This almost invariably not only covers the average rate of consumption, but the small night flow and the peak load.

In testing large meters with this apparatus and with from 15-20 ft. of hose under 50 lb. pressure, one is able to test flows as large as from 450-500 g.p.m., which in all ordinary cases is ample. Of course, for the low flows, for which the ¾ in. or 1 in. meter is used, one is able to test the minimum rate at which the meter to be tested is guaranteed.

Why Velocity Meter Is Used.—There are two reasons for using the velocity meter. The loss of pressure is very low at high rates, and at the same time the velocity meter will pass sand and small particles of dirt without interfering with the registration. There is also a strainer on the bottom of the measuring chamber that will stop foreign matter which is large enough to retard registration. I am not inferring that most water departments have more or less sand in the water, but in running these tests, especially on flows larger than the average consumption, if there is any accumulation of sand or dirt in the pipes at all, it will be drawn through the test meter. Of course, this is not true of the smaller rates of flow through the ¾ in. disc meter.

In testing any type of compound meter, it has been our practice to test

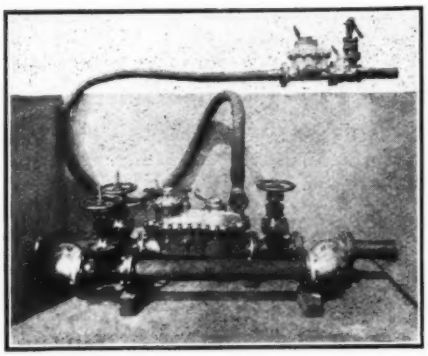


Fig. 3—Installation of 4-in. Compound with Bypass and Test Meters Attached

the smaller flow first, so that if there is any error in the meter it can be segregated. If on testing the bypass meter, it is found to be in error, this error is corrected before running flows that are registered on both the main line and bypass meters.

We have no specified rates of flow at which we test meters in the field, as we allow the superintendent to designate the test rate he wishes us to run, because in a good many cases, the superintendent has a very good idea of the average rate of consumption through the meter. Before making these tests, the test meter is tested in our testing department and the test card attached to the meter before it is shipped.

Setting Meters.—Before closing, I would like to say a few words on a subject not of testing, but which is very closely related to it, i. e., pits in which the meters are set. I have seen meters set in pits so small that the top of the pit had to be removed before one could hook up the test apparatus. I have seen a meter set with a 3 in. gas pipe crossing over the top at right angles and clearing the meter by not over 6 in. In a number of cases, meters are set in pits so narrow that a man could not remove the meter bolts except with a socket wrench or a hammer and chisel. Of course, this is unavoidable in a good many cases owing to other underground conditions, but if the man in charge of building meter pits kept in mind the fact that the meter might eventually require repairs, and that in all probability the work would be done in the pit, I believe we would find the pits larger. If the meter cannot be set without the cover being close to the top, dig the pit 18 in. or 2 ft. below the bottom of the meter, and if possible, have a drain in the pit. This will not only help the repair man, but also will assist in keeping the registers cleaner.

Acknowledgment.—The above is an abstract of a paper presented Sept. 18 at the 48th annual convention of the New England Water Works Association.

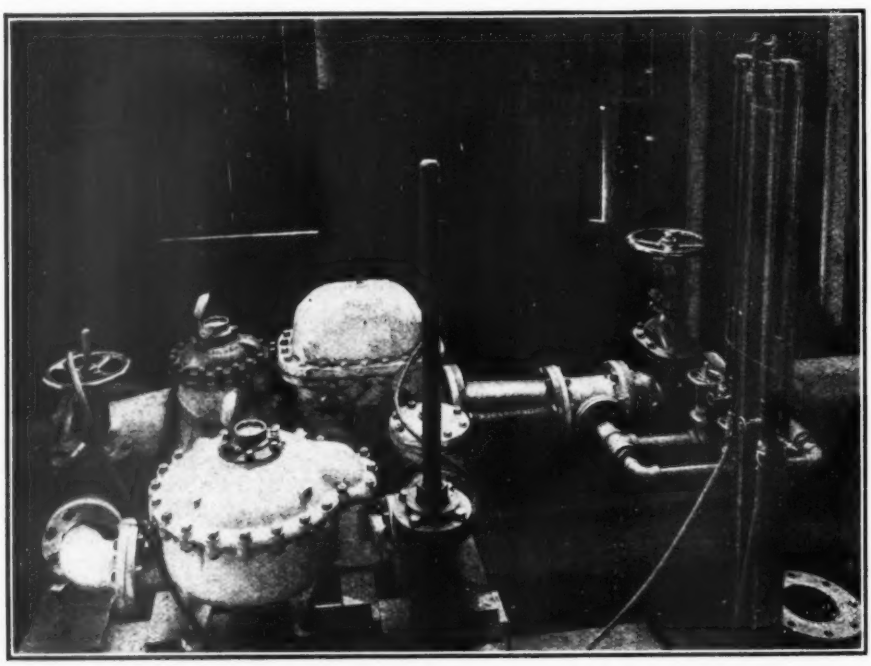


Fig. 2—Showing Mercury Column to Obtain Loss of Pressure Across the Meter

Field Mice Attack Trees on Water Shed

An effective campaign against the field mice, which have been attacking a large number of the 40,000 to 50,000 Scotch pine trees planted three years ago in the 40 acres of forestation for the protection of the watershed at Lock Raven, has been started by Water Engineer Edward G. Rost of Baltimore, Md.

The mice have been attacking the trees in the fall and winter months after the vegetation starts to die and they can find nothing else upon which to feed.

The damage to the trees was discovered after the needles on the trees had turned brown and there was other evidences of decay. While the attack has been made chiefly upon the young trees the mice have not overlooked some of the older and taller ones.

Experts from the United States Department of Agriculture were called in consultation and after an examination stated they believed the trees were victims of spittle bugs.

A later examination by Mr. Rost disclosed holes at the base of the trees. Upon removing some of the soft dirt with his hands Mr. Rost found the bark at the roots had been eaten away and this led him to believe the destruction was due to mice. The bark on the trunk of the trees also had been eaten in places by the rodents.

After the setting of 100 wire traps failed to render the desired effect Mr. Rost held a conference with F. N. Jarvis, in charge of the Eastern Rodent Control District of the Biological Survey of the Department of Agriculture, and it was decided to place poisoned oats in the runways on the watershed near the trees for the purpose of exterminating the mice. It is known the rodents will eat the oats in preference to any form of vegetation and it is hoped by this means that the offenders will soon be exterminated.

Two-Main System of Water Distribution

Experiences in Chicago Show System More Economical Than the Single Main System

By J. B. EDDY
Engineer, Water Pipe Extension, City of Chicago, Ill.

THE city of Chicago has adopted a definite policy regarding the use of the two-main system of water distribution. While not used exclusively for all new installations, its advantages are kept in mind and whenever the benefits to be derived warrant it, the two-main system is used. No hard and fast rules have been adopted, each installation being considered on its own merits; however, in car line streets, wide boulevards, newly widened traffic arteries and in streets 80 ft. wide, with fronting lots, two mains are laid. The first street in which two mains were laid in place of one was a "downtown" business street.

Replacing Old Main with Two New Ones.—During the years from 1907 to 1912 inclusive, pitometer surveys were in progress in and adjacent to the central commercial and business section (known as the Loop district) of Chicago. Elimination of underground leakage was a part of this work, special attention being given to streets about to be paved. In this section of the city many services had been abandoned where large buildings occupying a number of lots replaced a number of smaller buildings. These abandoned service pipes, of lead, were often battered shut where cut near the curb, many opened up from the effect of pressure, and sand washing quickly enlarged the opening. The result was usually an underground unobserved leak—growing as time went on until many were discharging the full capacity of the service. This section of Chicago has a sandy subsoil over which usually were placed, as the street grades were raised, cinders or other fill, making easy the escape to the sewer of underground water. Under such conditions it was necessary that the water system be thoroughly overhauled prior to repaving.

The 6-in. main in Randolph St., La Salle St. to State St. (three blocks), was tested for underground leakage in 1910 previous to repaving. The tests were made at night because of the density of daylight traffic and the inconvenience to the public which would result from a shutoff made during the daytime. Underground leakage amounting to approximately 200,000 g.p.d. was measured.

This 6-in. pipe was laid about 1855 as a part of the original cast iron system. Later, filling placed in this street gave the pipe a cover of about 10 ft. Street car tracks were laid over the 6-in. pipe, the location of the main at State and Randolph Sts. being about 1 ft. south of the center line of the street. After a comprehensive study had been made it was decided to replace the old 6-in. with two new mains, one 12-in. to extend from State St. to La Salle St. adjacent to the north curb, and one 8-in. to be laid adjacent to the south curb in blocks requiring services.

Considerations in Installing Two Mains.—The reasons for this decision were as follows:

1. It would be very costly to locate and stop the underground leakage.
2. Traffic would have to be diverted to other streets while repairs were being made, which would greatly inconvenience the business houses on this street and the public generally.
3. Additional supply, both for fire and commercial use, was necessary.
4. Service pipe stubs not in use could be abandoned.
5. Live services could be retapped to the new mains, thus eliminating all piping beneath the car tracks (except at cross streets), making less service pipe to be maintained and reducing the electrolysis, known to be active in this street.
6. Future large service pipes for fire and commercial use could be installed at greatly reduced cost.
7. The mains near the curb lines could be maintained with little inconvenience to the public and at less cost than the old main beneath the street car tracks.
8. No main would be laid on the south side of the street between La Salle St. and Clark St. because of no service requirement. Fire protection in this block would be furnished from the 12-in. main.

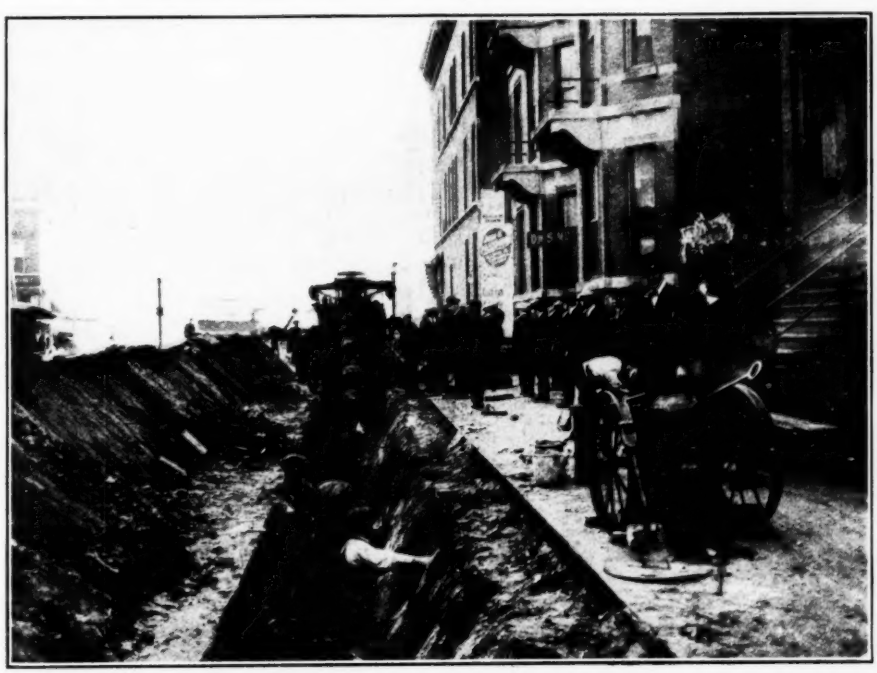
The factors given greatest weight in the conclusion reached were:

1. Public convenience.
2. Future maintenance cost.
3. Additional supply.
4. Elimination of underground leakage.
5. Electrolysis mitigation.

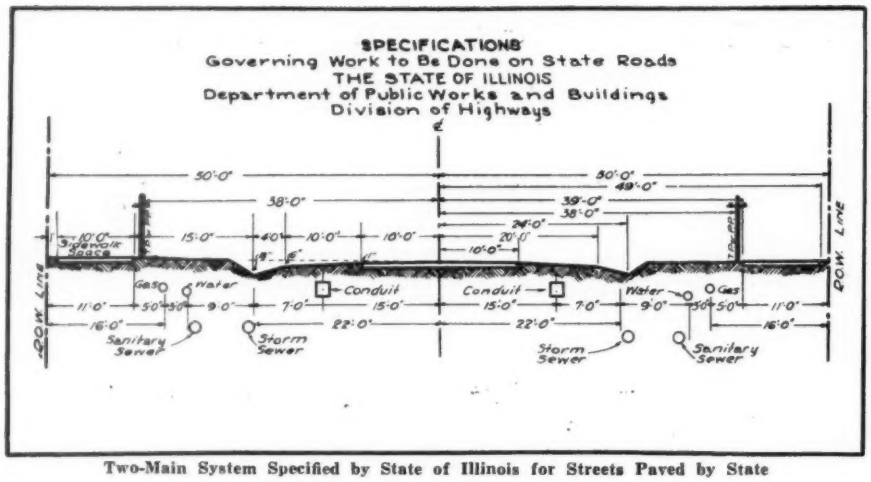
The 12-in. and 8-in. mains were installed in 1910 and this marked the beginning of the use of the two-main system in Chicago.

Since this work was done, similar investigations have been made in other loop streets until now many of the streets in the downtown section have two mains.

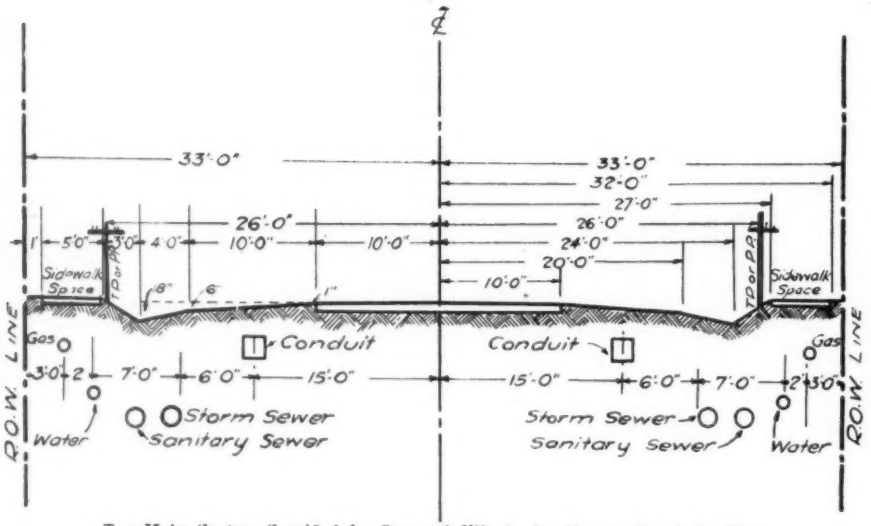
Water mains in the loop are not laid in the sidewalk space because this space is usually occupied for storage and other purposes. Variations of the two-main system exist, mains being laid in alleys, only one main being laid where service requirements are such as to make two mains unnecessary. In some streets having street car tracks the old



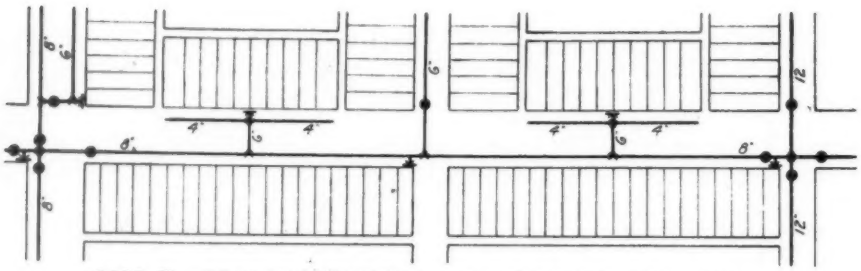
Trenching on Michigan Blvd. in Chicago Showing the Space Between the Pavement and Sidewalk in Which the Main Was Laid



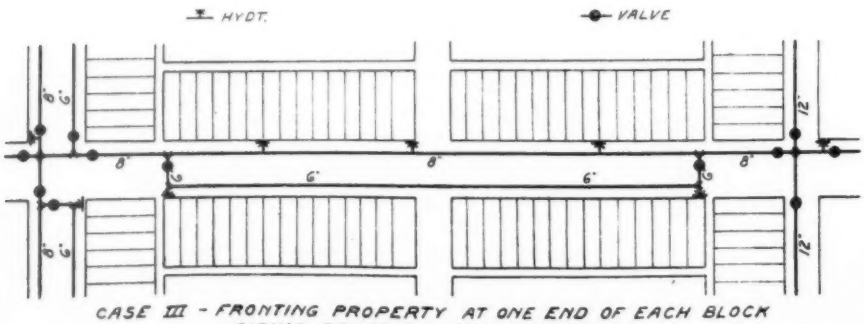
Two-Main System Specified by State of Illinois for Streets Paved by State



Two-Main System Specified by State of Illinois for Streets Paved by State



Plan for Mains for Fronting Property on One Side of Street and Parts of Other Side of Block



Plan for Mains for Fronting Property at One End of Each Block, Siding Property at Other End

main was in such a location as to be readily accessible. In such streets a second main was laid near the opposite curb, the old main overhauled, and the services in use to the opposite side of the street reconnected to the new main. All service pipe stubs were shut off at the main.

Laying Mains in Michigan Blvd.—In 1922 the roadway of Michigan Blvd., from Roosevelt Rd. to 33rd St., was widened about 7 ft. on either side and paved. The old 6-in. water main was located about 10 ft. west of the center line of this 100-ft. street, and had given much trouble when repairs were made and when large services had to be installed due to a change from residential to commercial occupation because of the danger to workmen and the inconvenience to motorists. Additional capacity was needed in this street.

It was decided to abandon the old 6-in. and install two 8-in. mains, one on either side of the boulevard. Trenches were excavated by digging machines excepting street intersections, which dug by hand. Each main was laid as near the new curb line as possible. It was necessary to cut the sidewalk for 10,560 ft. of this improvement. In the remainder there was a 7-ft. parking space in which the pipe was laid. The amount of pipe laid was 23,720 ft. and the time required for the work was about four weeks.

Many old service pipe stubs were abandoned.

All live services were reconnected. The cost of this work was $2.95 per foot, the material costing $1.60 per foot.

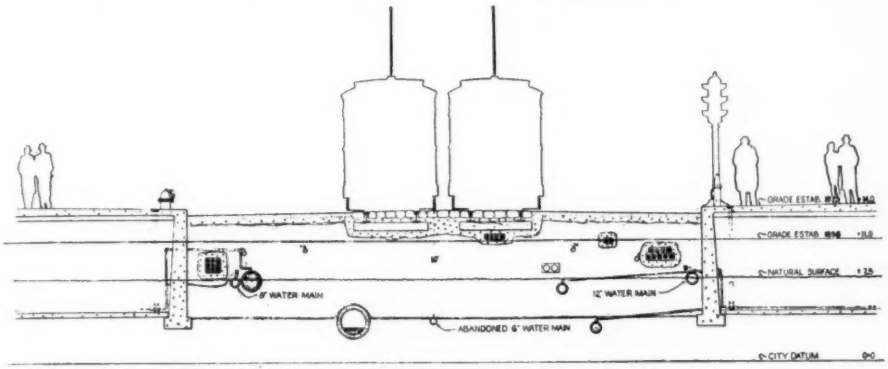
Factors to Be Considered.—Whether or not the two-main system is used in Chicago is not always determined by first cost. It is installed in business streets, car line streets and boulevards because it has been shown by experience that after installation in such streets the two-main system causes less inconvenience to the public and is less costly to maintain than one main with long services.

In all residence streets of less than 80 ft. in width, except state roads, an estimate of cost is made to determine which system shall be installed. However, there are many factors which should be considered in addition to first cost when deciding whether or not to use two mains.

Usually the street pavement is laid a very short time after the water main and service stubs have been installed, and for this reason pressure is being exerted to have all excavated material other than sand or gravel hauled away and sand used for backfill, so that the pavement can be laid immediately following the completion of underground utility work. This provision has been enforced a number of times within the past few years and the cost of hauling away excavated material and hauling in sand, plus the cost of one main and long services, greatly exceeds the cost of two mains back of the curb lines.

Of course, it is necessary that traffic arteries be out of service for repaving as short a time as possible, and sand backfill aids greatly in cutting down the time of making the improvement and insures that the new pavement will not settle over newly made trenches. It does not assure that the new pavement will not be cut to make repairs, and therefore when no main has previously been laid it is better to lay two mains inside the curb lines, which makes the sand backfill unnecessary and places the pipes where they are readily tapped or repaired without going into the pavement. Also, mains and services need not be laid, except crossings, until water again the weak spot has been the wiped joint.

Two-Main Systems for Streets Paved by State.—The state of Illinois requires the two-main system where streets and roads are paved by the state. Standards are provided in the state specifications for arrangement of pipes, sewers and conduits for rights-of-way varying from 50 to 100 ft., two of which are shown. Provision is made that all pipes, sewers, and poles shall be placed outside of a 40-ft. strip which centers on the center line of the right-of-way. The conduits are located so that they clear a 20-ft. pavement but lie under a 40-ft. pavement.



Cross Section of Randolph St. Showing Abandoned 6-In. Main with Existing 12-In. and 8-In. Mains and Utilities

for service and fire protection is actually needed. Streets have been treated in this manner in Chicago with satisfactory results, the paving in some cases having been down for five or six years before water was required in the street.

Causes of Leakage.—In connection with the overhauling of mains and services, prior to paving, it has been found that the lead service pipe is a greater source of underground leakage than the cast iron main. From 1916 to date, 966 service pipe leaks have been repaired which showed a measured leakage of 5,336,000 g.p.d. During the same period 429 main leaks have been repaired which gave a measured leakage of 3,590,000 g.p.d. The service pipe leaks are usually at the wiped joint either at the coupling to the tap or at the stop-cock, more frequently at the former.

The point is that the number of wiped joints can be greatly reduced where two mains are installed because service pipes are laid only when and where required and not for every lot. Furthermore, where no trenches are dug crossing the sewer there is a greater possibility that the leakage will show up at the surface since trenches give easy access to the sewer.

In connection with maintenance work, 68,998 service pipe repairs have been made as compared with 41,459 main repairs from 1916 to date. No measurement of leakage has been made in connection with this work, but here

In a number of streets that were being repaved, it was found economical to abandon the old main and lay two new ones. The old main in each case was obsolescent, badly corroded by electrolysis, inaccessible, or it was known that the cost of digging it up to salavge would exceed the value of the pipe. Old mains, where accessible and in good physical condition, are always overhauled before a street is paved, leakage being located and stopped and abandoned services closed off at the main.

Variations of Two-Main Systems.—Many variations of the two-main system may be used. A street may have solid frontage on one side and partial frontage on the other, in which case the plans shown in the illustration may be used.

In some sections of Chicago the two-main system has been used almost exclusively.

Experience in Chicago with the two-main system has been most satisfactory and demonstrates that in the last analysis, this system is more economical under the conditions where used than would be the single main system. The saving in initial cost of service pipe, the lower maintenance cost, the additional capacity, the better fire protection, the reduction of electrolysis, all contribute to economy.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 1929 convention of the American Water Works Association.

Filter Material for Sewage Trickling Filters

The American Society of Civil Engineers Committee on Filtering Materials for Water and Sewage Works, which has been investigating this subject for several years has a progress report in the September Proceedings of the Society. The following tentative conclusions are given on testing and selecting filter material for trickling filters:

(a) Material for filter media should be sound, hard pieces with all three dimensions as nearly the same as possible, clean and free from dust, screenings, and other fine material. It should be of as nearly uniform size as possible, and the material should not disintegrate under service conditions either by breaking into smaller pieces or by crumbling into fine material.

(b) In selecting the most suitable material for a given installation from the available sources of material, careful investigation of the several sources of material should be made, including geological inspections of quarries, a study of the facilities for obtaining, screening, and cleaning the desired size of material, and a laboratory analysis of samples selected from the several sources to determine the comparative merits of the several materials as to the probability of the breaking down of the materials under filter service conditions. For this laboratory analysis samples should be selected from the various ledges in the several quarries or from the several possible storage piles.

(c) The investigation of the Committee to date indicates that the sodium sulfate soundness test is the most indicative test for predetermining the disintegrating qualities of the proposed material. Other physical tests, including the determination of specific gravity, the absorption, and porosity, give useful information. Chemical analyses are of value in determining the effect of impurities, such as earthy materials, iron, and sulfur, and, in some cases, lime and magnesium. Micro-structural analyses made by properly qualified examiners may also be useful.

(d) Great care should be taken in obtaining the filter material from a selected source to insure a uniform grade and size, free from dirt and fine matter. There is evidence to indicate that improper screening for size and cleaning of filter material for many of the existing trickling filter installations has been of influence in the deterioration of the filter beds, perhaps more so than the matter of breaking down or disintegration of the individual pieces of filter materials. It appears that proper sizing and cleaning of filter material cannot be obtained without special arrangements for screening and rescreening and perhaps washing of the material either at the source or at the filter plant immediately before placing the material in the filter bed.

Water Works Management

Essentials in Successful Management of a Municipally-Owned Water Works System

By H. E. MOORE
Secretary, City Water Works, Dallas, Texas

FOR the purpose of discussion I shall refer only to the municipally-owned water works system, though in my opinion the holder of any privately-owned franchise of this nature should live up to the same high purpose or forfeit the privilege granted him. No corporation has the right to make a profit from any public necessity unless it honestly and squarely studies the needs of the community supporting it, and endeavors to fill adequately the purpose of a water supply, that is city building.

Three Factors of Community Growth.—The question of water supply has always been a vital factor in human history. No civilization has ever developed without at least an adequate supply of fairly pure water. The modern age was ushered in by the three big factors of community growth, demand for sanitation in its various phases, and industrial development. Fire-fighting facilities I would class in the item of community growth. Under the term "sanitation" we can include both the direct health factors and the more indirect items of aesthetic value such as street cleaning, parks with wading pools and landscaped grounds, and similar demands which any community now makes upon the water supply system. It is not at all difficult to realize that the person responsible for the management of a water works systems has demands upon his abilities and activities which require real consecration to the task at hand. Let me change one letter in the title of my subject and make it read, "The Problem of Water Works Management." This problem is to keep a broad outlook and constantly survey the market for the commodity he is dispensing; to plan for future needs due to growth; to keep his rate schedules intelligently adjusted to the shifting requirements from the super-industry of which his department is a part, building desirable, healthy cities for people and encouraging the industries which supply their need of a livelihood. The need for uniformity of supply, accurate records for the distribution system, an adequate distribution system, and a proper accounting system, are all more or less important parts of the major structure centering about one individual. The wise manager will solve these various needs by selecting competent heads for the different divisions, and then lean heavily upon them. Thus his mind is relieved of a multitude of detals and left free to think and plan along broad constructive lines.

Water Department Vital Factor in Growth of Town.—The problem of management is to get a vision of the possibilities and organize the department with a view to placing it in the first rank of leadership for the town which it serves. A well-balanced population center under modern conditions of necessity requires more or less industry to be self-sufficient and thiving. The demand for plenty of pure water for domestic and sanitary uses at reasonable rates is logical and must be satisfied. Right here is the largest source of grey hairs for the manager of a municipally-owned water system. His actions are unfortunately often more or less circumscribed by the political influence of his customers. These customers are ever ready to exercise the voting power in an effort to force cheaper domestic rates, regardless of the economics involved in our rate schedules. The tendency to put water departments under separate boards fairly free from political influence is going to measurably improve this condition. We must be cautioned, however, that with more freedom of action comes greater obligation to use due business principles to keep the domestic end of the rate schedules where they fairly belong from an economic standpoint. Abuse of this feature, with more freedom from the undue influences, will discredit the idea and offset the progress made. An efficient and fairly operated water department under a non-political management will in a few years gain a hold on the minds of a community that no municipal storm can shake. The public always approves efficiency and just dealings in the end. We must admit that most of our troubles from this source are due to a more or less justifiable reaction of the public to our overbearing attitude in the past.

Water Supply a Fundamental Factor in Industrial Growth.—The three fundamental factors of industrial growth are: (1) Cheap and dependable fuel; (2) cheap power; (3) cheap and abundant supply of pure water.

Lying within the boundaries of our southwestern states is enough lignite coal to supply the present and future needs of great industries. It can be obtained very cheaply by any community in this section. Development of this asset has been started on a large scale. In Oklahoma and Arkansas coal fields are high grade steam coal available at reasonable cost. We have cheap fuel oil from our oil fields, and gas for industrial purposes is in extensive use with ample supply. Power and light companies have developed an adequate and dependable source of cheap power for our needs. Now let me ask how many cities or towns represented here have a vision of their water supply system as a vital factor for the necessary industrial growth? It is really the most important of the three named, and belongs to the citizens of the respective communities. As a stockholder in the municipality every resident is interested in this question. It is in this connection that the need for scientific study of the rate schedules in effect exists. The bookkeeping system should include a method to give monthly summary sheets showing a summary of consumption recorded. They should separate accounts into amount-consumed classifications. In addition it should be the function of some one trained in such matters to analyze them and from time to time investigate the idea of adjustment to more equitably distribute costs and make the department function as a civic asset industrially.

Public-Relations Man Needed.—To my mind every water department logically needs a commercial agent or public-relations man whose sole duty is to sell the citizens on their own asset and study just such questions as I am raising. Every large concern selling a public service has a large commercial department with trained employes endeavoring to keep the charges of the concern intelligently balanced to the conflicting demands for meeting all costs and developing more markets for the commodity they have to sell. Of course you can readily understand that in smaller cities all the needs I am enumerating will logically center in the manager himself. This fact emphasizes the importance of putting competent, properly-trained men in charge of the water departments of such places.

Let the thought I leave with you be a resolve to study our water departments with the view to making them fulfill the mission I have outlined. The welfare of a growing town or city is bound up with the proper functioning of its water-supply division on a sound business basis. It is good business for a city to encourage the location of industry sufficient to supply every breadwinner with a job. When factories are seeking locations they weigh carefully the present and probable cost of the water supply necessary to operate in any site under consideration. Specifically I know that the present rate in Dallas has been one of the stumbling blocks to the chamber of commerce program for industrial development. This defect exists generally in this section and should receive our most earnest thought. In my own department we are studying this particular point and trying to map out a forward-looking plan to be the vital factor in our city's growth that the water department can and should be. Due to past circumstances similar to those in the history of large cities especially, most large buildings and factories have their own water supply in Dallas. Now the reason for existence of water works systems is that collectively we can have greater convenience, more ample supply, and better quality, at lower cost than individually. With adequate supply of high quality it is the essence of wisdom to get this business all con-

nected to the one system. Through that increased business the industrial water rates can be lowered below the cost of any individual system and serve to aid rather than retard the proper expansion of the city. We all operate on a "service-at-cost" basis and serving large users means to us ability to better serve the community of which we are so important a part.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 11th annual Texas Water Works Short School.

Well Water Supply

Details That Should Be Considered

By W. KIERSTAD, JR.
Consulting Engineer, Kansas City, Mo.

MECHANICAL equipment of all kinds has been vastly improved during recent years. Well pumps have not lagged behind the procession in the march of progress but have been steadily improved until now equipment is available for the most difficult well pumping problems with many, if not all, of the old operating hazards removed.

Higher efficiencies are attainable, better materials are available for all wearing parts, improved types of bearings are replacing the ones which have been used in the past, more accurate methods of machine work are being employed, better workmanship by mechanical methods replaces much but not all of old craftmen's handwork and improvement in the actual design of critical parts are all the fruits of years of experience and painstaking effort on the part of manufacturers and operators alike to perfect well pumping equipment.

There is a definite and praiseworthy tendency on the part of pump manufacturers to standardize articles which they manufacture in the minutest detail. Such practice results in economy of production, uniformity of product and the most extensive interchangeability of parts possible. Competition in turn brings the saving in cost back to the user of the machinery and the standardization of parts facilitates maintenance.

Conditions Must Be Analyzed.—Nature, on the other hand, cannot be so standardized. Each well project must be carried out and the wells pumped under conditions that by nature are likely to differ to a degree from conditions at any other well site. We find with all of the mechanical improvements and highly specialized machines that now, more than ever before, it is necessary to make a careful preliminary analysis of conditions under which the pumps are to operate if full benefit is to be derived from highly efficient pumps and from the experience of those who have designed, improved and operated them.

Disappointment is sure to follow the blind selection of well pumping equipment just as it would be the purchase of a Packard pleasure car to perform the services of a 5-ton truck of equal value. A pumping unit which suits certain conditions admirably may fall far below the standards set by some other type of pump when installed without giving due and careful consideration to the natural circumstances and limitations surrounding the installation.

Careful Studies Desirable.—Much valuable information as to the depth, thickness and extent of the water bearing formation, the quality of the water and probable yield can at times be obtained from geological reports and from existing wells. Such information should be received and regarded with caution, however, unless the ability of the field to furnish an unfailing supply in the desired quantities has been definitely proven. Domestic wells have frequently been reported by their enthusiastic owners to be "inexhaustible," but which quickly dried up when a well was sunk in the locality and used to furnish water for a public supply. A considerable amount of money may be well spent for investigation, borings and test wells before committing the expenditure of a much larger amount to any public well water supply project.

In the absence of adequate preliminary studies the physical characteristics of the ground through which the well is to be drilled will remain pretty much an unknown factor until drilling operations are far advanced or even completed. Soft caving ground may be encountered for which support must be provided. Strata of mineralized water may be passed through which have to be sealed off from the desired supply, boulders or non-uniform material may be encountered causing a crooked well or numerous other difficulties may arise which affect to an important degree the type of well to be constructed, drilling methods and equipment to be employed and at last the pumping machinery to be installed.

Underground velocities vary widely, depending upon the fineness of the water bearing formation. The velocity in turn has a material affect upon such well characteristics as yield, drawdown, sand content of the water pumped and also upon the number and spacing of the wells which a given district will support or which will be needed for an adequate supply.

Pumping Rate and Water Level.—This depth to water varies from a few feet to 1,500 ft. or more but the approximate depth to the desired water bearing stratum is generally a matter of common knowledge in any locality. The development of the first well or the test well will reveal accurately the level to which the ground water will naturally rise during different rates of pumping. These relations between pumping rate and water level may not remain the same over a period of years, particularly if ample provision is not made in the development process to prevent packing of sand and fine material around the strainer but it is largely upon this initial relation and knowledge of the methods of development that the water supply engineer must base his judgment, seasoned with experience in other localities, as to the best type and size of pumping unit.

Selection of Pumping Equipment.—It will always prove advantageous to defer the selection of pumping equipmene until after the well, or at least one well where a group is to be drilled, has been thoroughly developed. Unless this is done equipment unsuited to the conditions will probably be purchased and unnecessarily high operating costs will folow. There is a tendency on the part of many at first thought to select pumps for a higher head or of larger capacity than actually needed. Such a tendency is prompted by a desire to provide amply for extreme conditions of head and pumping rate, particularly in view of the low additional cost of larger pumps.

It would be far better, however, in endeavoring to provide an ample supply of water to drill two or more wells, pumping a nominal amount of water against a low head from each than to overtax a single well with a large sized and generally over-designed pumping unit. By so doing one often defeats his own purpose, causing the well to fail altogether by clogging on account of the high rates of flow or at least finding that the cost of pumping water is unreasonably high, due to low operating efficiency.

It is, furthermore, too frequently the practice to continue using a pump until because of wear and tear it fails to lift a sufficient quantity of water to meet the demands of the city and in such cases where an over-sized pump was originally installed the cost of power for operation at partial loads will be found to have increased to an excessively high figure before the much needed repairs are made.

Where a plunger pump is operated at a rate above the yielding capacity of the well so that it takes air the running of the pump becomes very uneven and the annoyance of rod breakage soon develops. Difficulties almost as undesirable, although not often so costly, are encountered in the operation of over-sized centrifugal or turbine pumps.

Pumps that are employed for pumping water supply wells may be roughly divided into four classes; deep well plunger pumps, deep well turbine pumps, air-lift pumps and centrifugal pumps of the vertical and horizontal types.

Each classification serves a definite field in the pumping industry, meeting particular requirements suited to it better than pumps of any of the other classifications.

Acknowledgment. — The above is taken from a paper presented at the 1929 Missouri Conference on Water Purification.

Re-Sanding the Cincinnati Filters

By CLARENCE BAHLMAN
River Water Purification Supervisor, Cincinnati, O.

After 21 years' service, preparations are being made to re-sand the Cincinati filters.

As originally constructed, the filtering medium consisted of 8 in. of graded gravel and 30 in. of sand with an effective size of .34 mm and a uniformity coefficient of 1.60, and this sand averaged 1.1 per cent soluble in hot hydrochloric acid. The gravel and sand layers were separated by a perforated screen. In 1916 the screen was removed and an additional 6 in. of gravel was added. This brought the sand surface to within 24 in. of the top of the wash water gutter, as compared with 30 in. when the plant started operation in 1907.

Increased Size of Sand.—Examination of the sand every 2 or 3 years has indicated a gradual increase in size and incrustations. In 1928 the sand averaged .50 mm effective size, 1.29 uniformity coefficient, 50.8 per cent acid-soluble, and the distance from sand to gutter top had decreased to 15.5 in. In other words, the original 30 in. of sand had expanded, because of incrustations, to 38.5 in. The composition of the incrustations, as shown by analyses made by the state health department, was as follows:

	Per Cent
Silica	3.5
Iron oxide	4.7
Aluminum oxide	2.8
Manganese dioxide	1.7
Calcium carbonate	83.1
Magnesium carbonate	1.5
Organic, by difference	2.7
	100.0

No decreased filter efficiency has been observed as the sand became more coarse, but re-sanding is in order because of losing sand during the washing process, in which an 18 in. vertical rise per minute is used. Such loss, however, first noted about 3 years ago, has been confined entirely to the winter months. It seems that the greater density of the colder water has a more pronounced flotation effect.

Careful examination of the gravel layer, strainer system and underdrains has indicated that everything was in satisfactory condition, and a complete reconstruction of the filter beds is deemed unnecessary. It is not intended to disturb the gravel, nor remove all of the old sand.

The degree to which the old sand left in the filters will mix with the finer new material has been studied experimentally. One square foot areas, of a filter were blocked off and excavated to the gravel, and various depths of old and new sand were placed in these boxes, following by washing rates of from 18 to 24 in. per minute. It is evident that more or less mixing occurs, and that the new sand to be added must be somewhat finer than is finally desired in the re-sanded filters.

How Re-Sanding Will Be Done.—The plan decided upon is as follows: The reconstructed filter bed will consist of the present 14 in. of gravel and a 28 in. layer of sand, and the surface of the sand is to be 26 in. from the top of the wash water gutter. At least 12 in. and probably 16 in. or more of the sand bed will consist of new sand. The upper 12 in. of the finished filter, after washing, should show an effective size of from .34 to .38 mm. with a preference of not below .36 mm.

Because of long and efficient service obtained from the present filters it is deemed advisable to re-sand with material from the same source, namely Ohio River sand. Costs also strengthen this opinion. Fine Ohio River sand will cost us $1.60 per ton delivered, whereas sand from Youngstown and from Illinois has been quoted to us at $6.29 and $6.90 per ton delivered.

The effective size of Ohio River sand ranges from .24 to .27 mm. Laboratory studies have shown that by screening such material we are able to produce a sand which meets our requirements of .34 to .38 effective size, and 1.30 to 1.50 uniformity coefficient. The desired fraction was that retained between two screens having openings of 0.97 and 0.29 mm. respectively. Approximately 73 per cent of the crude sand was thus rendered fit for use, with a wastage of 8 per cent pebbles and 19 per cent silica dust. It was also found that the sand should be dried before screening, otherwise too much of the fine material was prevented from passing through the lower screen.

Drying and Screening Sand.—The grading of the crude sand therefore requires both drying and screening equipment. A rotary sand dryer heated with a kerosene burner was purchased, and after some alterations this was made to function satisfactorily. For screening the sand we have purchased a W. S. Tyler two-surface inclined electric vibrating screener. Two 4 ft. x 5 ft. screens are used, namely Tyler's No. 817 Ton Cap for the upper screen, and Tyler's 35 mesh, 0.013-in. opening steel screen for the lower surface. When inclined, the effective opening of these screens are equivalent to the opening of the laboratory screens which were used in horizontal position.

Preliminary trials with this apparatus produced sand averaging .345 mm. effective size and 1.51 uniformity coefficient; which seems to be just about what we require. Should screening on the large scale produce a somewhat finer or coarser product than anticipated, a change in the angle of screening will at least partially rectify the deviation. The measurements of the upper 12 in. of the new sand bed in the finished filter can also be controlled, within limits, by adding somewhat more or somewhat less than the 16 in. of new sand which it is expected will be needed in each filter. Thus two points of adjustment are available for correcting any differences between laboratory and actual results in practice.

That the re-sanding of the filters is an undertaking of some magnitude is apparent. To place 16 in. of new sand in the filters, assuming a wastage of 30 per cent in the screening process, will involve the drying and screening of 2,800 cu. yd. of sand, or about 3,800 tons. About the same amount of old sand must be removed from the filters and transported about 900 ft. to a waste pile. It is planned to do this with a hydraulic sand ejector and thence through a 4 in. pipe. A three-floor shed will be erected to house the drying and screening equipment. The sand will be unloaded from the hopper-bottom cars by means of a portable conveyor, which also will be used to elevate the sand to the dryer on the top deck of the shed. The dried sand will spill into the hopper of the screening machine on the second deck, and from here the 3 fractions of sand will be chuted into 1-ton industrial cars on the ground floor.

Acknowledgment.—The foregoing is a paper presented at the 8th annual Ohio Conference on Water Purification.

New York State Sewage Works Association to Meet at Schenectady

The fall meeting of the New York State Sewage Works Association will be held Oct. 19 at the Hotel Van Curler, Schenectady, N. Y. The program follows:

9:00 A. M.—Registration.
9:30 A. M.—Short description of Schenectady Sewage Works and General Electric Co. Industrial Waste Disposal Plant—Morris M. Cohn.
10:00 A. M.—Inspection trip to described plants.
12:00 Noon—Meeting of Executive Committee.
12:30 P. M.—Luncheon—Address of Welcome—Mayor Henry C. Fagal.
2:00 P. M.—Business Session.
3:00 P. M.—Technical Session (Papers, Discussions) "Present Status of Sewage Treatment in New York State"—C. A. Holmquist.
3:40 P. M.—"The Treatment of Milk Wastes and Whey"—Prof. C. L. Walker.
4:20 P. M.—"The Relation of Designing Engineer to Plant Operator"—H. B. Cleveland.
5:00 P. M.—"The Problem of Interception and Treatment of Buffalo's Sewage"—C. L. Howell.
6:00 P. M.—Dinner.
7:15 P. M.—Round-Table Discussion on Sewage Works Problems.
9:00 P. M.—Candle-light Dancing—Hotel Van Curler.

Round-Table Discussion Topics

Is Imhoff sludge saleable?
What are your odor problems?
Have you a rat menace at your plant?
What are you doing to awaken local interest in your plant?
Have you found a paint to withstand plant conditions?
How do you control your filter flies?
Are there any questions on the operation of the plants you have inspected at Schenectady?
What phases of plant operation need research?
What should this association do to sponsor sanitary engineering courses in colleges of the state?
What do you think of licensing operators?

Service Installation at Detroit, Mich.

By L. J. MONTGOMERY
Principal Water Permit Clerk, Department of Water Supply, Detroit, Mich.

The permit bureau has charge of issuing all permits for the installation of service connections and meters. As the work connected with the installation of water services and meters is an important part of building operations, stringent regulations have been adopted by the board of water commissioners to govern plumbers and plumbing, which are altered from time to time to meet changing conditions.

All master plumbers doing work in connection with the department must have a license both from the department of health and the department of water supply of Detroit, to secure which the plumbers must pass an examination in the art of the plumbing craft. This examination is conducted by the board of examiners of plumbers at stated intervals in the office of the board of health. After the plumber has passed this examination and presents his board of health license, the department of water supply issues its license, for which there is an annual fee of three dollars.

Procedure for Securing Service Installation Permit.—In applying for service installation the plumber is required to fill in a blank form, giving the street name, side of street, between streets, lot number, whether to supply a new or old building, owner's name and address. This he takes to our engineering department to check for main assessment and to secure location of main, size and width of street. When the permit is issued the plumber is given a stake bearing the number of permit. He is required to set this stake just inside of walk at the point where he wishes this department to enter with the service. The permit is then taken to the numbering department, city engineer's office and a house number is secured for the lot which receives the service. A typewritten order, which is a copy of the application, is then sent to the central storage yard and in due time the work is performed by the service installation department. At the time this is done the plumber's work from the house to the lot line is inspected to see that it compiles with the board's regulations as to depth, kind of pipe, etc. Should a delinquency exist, the plumber is notified that it must be corrected before further permits will be issued him. Should the Board desire, his license can be temporarily or permanently suspended.

The minimum size service pipe allowed is that of a ¾ in. This has been found of sufficient capacity to furnish a single house, two-flat, store and flat with tank closets, an adequate supply of water. Four-family flats must have at least a 1-in. service. Large apartments, commercial and industrial properties are allowed any size connection necessary for their supply. All service pipes must be of lead or cast-iron.

When application is made for a new tap the property to be served is checked in our register of connections and if any old connections are found to enter the property they must be removed at the street main. A charge of $20 is made for each old tap removed. When a new tap has been made and service installed this Bureau is notified by the service installation department, which furnishes the location of the stop-box controlling the service. This location, together with size of tap, date of issue of permit, plumber's name and permit number are recorded in ledgers used for this purpose. These ledgers carry a plat of all streets, lot numbers and the feet frontage of each lot. As the plumbers make application for new services these are compared with the records already existing, which serves as a check on the plumbers' information as to the correctness of the property's description to be served. This bureau records a list of all master plumbers, together with their addresses, telephone numbers, etc., so that they can be easily communicated with and notified of any new regulations enacted or any changes made in existing ones.

A record of all paved streets is maintained, giving age of pavement, this being necessary in order to make the charge for pavement cuts, as required by the city charter. A typewritten form, carrying all information on the application for new service, is furnished the rate bureau and these are filed in numerical order, giving permit numbers, and as soon as the tap is made the service installation bureau notifies, who in turn makes out a reader's slip and these slips are entered in the meter reader's books and are reported on by them from this time until the property becomes occupied. When occupied this report is turned in by the rate bureau to this bureau and the order for meter setting is sent to the central yard by us. When the meter is installed this and the rate bureau are notified and we make our records read accordingly.

All water services must be metered. Where services are installed to supply properties outside of the city, it is necessary for the owner to purchase the meter in all cases where we collect the rates. The plumber makes out an application, giving full description of the property to be covered, location of meter, etc., and, upon filing same with this Bureau, he is given a templet.

City Furnishes Meters.—The department of water supply furnishes, without cost, all meters up to and including 1-in. for residential purposes and up to and including 2-in. for commercial and industrial uses. The size of meter allowed is governed by the size and height of building, number of fixtures and the probable need of water. Where application is made for meter of a larger size than that furnished by the board, the owner pays the difference in price. In no case, however, will the Department set, or allow to be set, a meter larger than that which will accurately register the water consumed. The department sets all meters and in the case of large ones performs the work from gate to gate after the remainder of the work has been done by the plumber in accordance with blue-prints furnished him. All meters are sealed after setting. In considering the size of the meter to be furnished by the department, all combination of business and residence property, if one or more floors are devoted to business, is classified as business premises.

All fire lines must be metered, the cost of the meter being borne by the owner of the premises served. An up-to-date record, by means of a card system, is kept of all meter applications and installations.

Acknowledgment—The foregoing is taken from a "descriptive survey," published by the Department of Water Supply of Detroit, Mich.

Dry Square Braided Hemp for Yarning Joints

By OTTO S. REYNOLDS
Traveling Representative, The Leadite Co., Kansas City, Mo.

The merits and economy in the use of dry square braided hemp are so evident at this time that many water works engineers and superintendents specify it on all bell and spigot work. There are several hemp manufacturers who carry it is a regular item. There are many water works supply houses throughout the country who also stock this material in 50 and 25-lb. reels. The material is made up principally in three sizes. The ½-in. square is the standard size, which is designed to fit all diameters of bell and spigot pipe from 4 to 16 in., inclusive. The annular clearance in the bells is designed to be uniform for the same class of strength and weight pipe. The ⅜-in. square is furnished to meet the requirements when a spigot of fitting is entered into a pipe bell, the clearance being close. Likewise the ⅝-in. square is furnished to meet the requirements on reverse conditions.

Braided hemp for the water works field should be purchased of a good quality. The standard ½-in. size, free from any treating compound, should run about 16 ft. to the pound, the undersize, ⅜-in., 25 ft. to the pound, and the over size, ⅝-in., 10 ft. to the pound. The material should be of a reasonably long fiber hemp. Like a rope, the longer and better grade of the fiber, the better the hemp. It should be strong to withstand the punishment of the yarning tool when being forced into the bell and not shear in two or break allowing an opening for the molten jointing material to run through into

the inside of the pipe. This incident causes delay in the progress of the work. Besides it is an unpleasant thing to overcome. There is little difference in the cost of a short fiber hemp from a long fiber. Therefore, the longer fiber hemps are recommended.

In the use of square braided hemp the hemp is cut to length allowing a lap of about 2 in. for 4 and 6-in. pipe; 2½ in. for 8, 10 and 12 in.; and 3 in. for 16 and over. On account of the various makes of pipe, specific lengths to cut hemp would be numerous and difficult.

In application, a length of hemp is held on the extreme end of the spigot end of the pipe. The worker guides the spigot, holding it close to the top of the bell. At his word another man at the opposite end or leading bell end with a stick forces the entrance of the spigot into the bell, and the hemp rolls in on the bottom at the same instant. Be sure the pipe is "homed" well. Then with the yarning tool, without a hammer, push the hemp back to the bead or centering ring of the pipe on the bottom. This can be done easily, as the pipe is loose in the bell and care must be taken not to push the hemp over the bead or by the centering ring. Then with the assistance of a hammer, force the hemp in along both sides, and then on top letting the lapping end lead downward, that the molten material will not force an opening between the lap and on into the inside of the pipe. This completes the yarning. For lead, usually two raps around the pipe is taken, which leaves exactly 2 in. for the lead on standard pipe. For Leadite, but one strand is used, which leave 2½ in. depth for the Leadite.

This method of yarning does not require any special tools. No preliminary rolling or twisting is necessary. It does not require the skill of a mechanic to center it, pack it and space it for depths, as is required with the open jute. It will not burn through, as the material is very closely braided. A very nicely centered pipe is obtained, which is the success of any joint. A uniform depth is obtained for the jointing material, which effects a saving on the jointing material in that an exact amount of it is assured of being installed and little chance for an excess being used. As this method of yarning is very easily applied, greater speed is accomplished and there is very little chance of injury to occur. The pinching of the fingers, which often happens when centering up a pipe with wedges preparatory to installing open jute, is practically eliminated.

With Leadite as the jointing material, square braided hemp is highly recommended, because it is believed much better joints may be had, and, as only one-half the material is required compared with lead and open jute, it is without doubt more economical. Lastly, if a strand of open jute should be left extending outward into the bell and then the Leadite be poured into the joint, it would remain there forming a conductor for a water leak, which would require cutting out and repairing. The Leadite is not hot enough to burn up the open jute, as would be the case with molten lead.

In braided hemp there is practically no waste to the material. The hemp is cut to exact length. It is not used for a rag to clean mud from tools, the hands or shoes. It is not used to wipe out the bells or spigots of the pipe. It is not used for starting fires, nor is it used to wad up and place into the end of the pipe for over-night at the end of the day—and sometimes overlooked to be taken out the following morning. It will not drive over and into the pipe to float about and possibly clog up a service or stick up a meter, both of which are expensive maintenance charges. Lastly, if a piece of hemp is dropped along the ditch, it is recovered, which is never the case with open jute, as the latter gets full of dirt and the yarner will not use it.

Many waterworks superintendents and engineers feel that, over the older method of yarning with open jute, dry square braided hemp is well worth its additional first cost, and that very good economy is effected in its use.

Acknowledgment.—The foregoing is taken from the July Journal of the American Water Works Association. The matter was prepared for a subcommittee of the American Railway Engineers Association, on revising railway specifications for laying cast iron pipe. Data are based on practice in Indianapolis, Charleston, S. C., St. Louis, Fort Worth, and Independence.

Ohio Conference on Sewage Treatment

The third annual Ohio conference on Sewage Treatment will be held at Canton, O., on Tuesday and Wednesday, Oct. 22nd and 23rd. The headquarters of the conference will be at the Northern Hotel where the meetings will be held. Tuesday afternoon and Wednesday morning will be devoted to the presentation of papers and to discussions, with a dinner Tuesday evening. An inspection trip to the Canton and Salem sewage treatment plants will be made Wednesday afternoon. The Canton works comprise Imhoff tanks and trickling filters. The Salem plant is a new one of the activated sludge type and employs a number of the modern devices for sewage treatment. Salem is 32 miles east of Canton.

Papers are being prepared on the following subjects:

1. The Canton Sewage Treatment Works.
2. The Salem Sewage Treatment Works.
3. The Biological Oxygen Demand Test.
4. Operating Details of the Small Sewage Treatment Plant.
5. Sewage Disposal Litigation.
6. Discussion of the Sewer Rental Law.

The Ohio Water Purification Conference will be held at Columbus, Oct. 24th and 25th, with meetings at Fort Hayes Hotel. Those persons wishing to attend both conferences can drive to Columbus over good paved roads, a distance of about 130 miles.

Reservations at Canton should be made early at either Hotel Northern (conference headquarters), Hotel Courtland or Hotel McKinley. Reasonable rates can be secured at these hotels. For those planning to go to Columbus it is imperative that early reservations be made at Fort Hayes Hotel, there being two other conventions in Columbus at that time. In making reservations at either Hotel Northern at Canton or Fort Hayes Hotel at Columbus mention should be made of the Conference being held there.

On Saturday, Oct. 26th, Indiana plays Ohio State at Columbus. A block of seats has been reserved for those members of the two conferences wishing to attend the game. Application for tickets, accompanied by check (price $2.50 each), should be made to T. R. Lathrop, State Department of Health, Columbus, O.

A detailed program of the sewage conference will be issued later from the office of the State Department of Health. Floyd G. Browne is Secretary Ohio Conference on Sewage Treatment.

Market for Dried Activated Sludge.—The Sanitary District of Chicago has given considerable attention to the development of a market for dried activated sludge from its Des Plaines River sewage treatment works and its Calumet sewage treatment works, and in cooperation with the Milwaukee Sewage Commission the district has done a large amount of successful experimental and promotional work. According to the 1928 report of Edward J. Kelly, Chief Engineer of the Sanitary District of Chicago, the activated sludge has proved excellent for uses on golf courses, particularly on the greens, and in gardens. For 1928, the price has been set at $25 a ton, f. o. b. cars at Maywood, in small lots, and $22.50, f. o. b. cars, by the carload.

Sewerage in Wisconsin.—According to records of the Bureau of Sanitary Engineering of the State Board of Health, 211 municipalities in Wisconsin have public sewerage systems, 91 of which have provided disposal facilities through 106 sewage treatment plants. In addition there are listed 9 sewerage systems and 3 treatment plants of a semi-public nature. During 1928 plans for 34 new, modified or extended sewerage systems were approved by the bureau.

Water Works and Sewerage

Published Monthly by

GILLETTE PUBLISHING COMPANY, CONKEY AVE. AND MADISON ST., HAMMOND, IND., AND 221 EAST 20TH ST., CHICAGO

Publishers of

Engineering and Contracting — Roads and Streets
Water Works and Sewerage — Tiles and Tile Work

Road and Street Catalog and Data Book
Water Works Catalog and Data Book

HALBERT P. GILLETTE.....President and Editor
E. S. GILLETTE.....Vice-Pres. and Secretary
E. B. HOWE.....Vice-President
E. C. KELLY.....Vice-President
T. F. KILROE.....Vice-President
J. M. ANGELL, JR.....Eastern Manager
C. T. MURRAY.....Managing Editor
VICTOR J. BROWN.....Associate Editor
CHARLES M. NELSON.....Associate Editor
H. J. CONWAY.....Make-Up Editor
L. R. VICKERS.....Distributor News Editor

Cleveland Office.....953 Leader Bldg.
New York Office.....420 Lexington Ave.
San Francisco Office.....703 Market St.

Subscription Price $2.00 — Foreign Postage 65c Extra

Copyright, 1929, by Gillette Publishing Company

Encyclopedia Britannica's Fallacious Argument Against Water Metering

Speaking of the use of water meters the Encyclopedia Britannica says: "But the worst evil of the (meter) system, and one which must always prevent its introduction into the United Kingdom, is the circumstance that it treats water as an article of commerce, to be paid for according to the quantity taken."

This argument is perhaps the one oftenest used against the metering of domestic consumers of water. There is a subtle fallacy in it that has deceived, and continues to deceive, many a man. Since water is as necessary to life as is air, it is argued that it should be as nearly free as possible. Indeed, Britannica adds: "In the organization of the best municipal undertakings in the United Kingdom the free use of water is encouraged." Now the matter of fact is that there is no such thing as free city water, even in the case of the man who pays nothing directly for it, because he inevitably pays indirectly in the form of taxes. The water tax then becomes part of his monthly rent, and so is lost to his sight but not to the sight of his landlord. So the question resolves itself to this: "Is it preferable to pay for your water directly or indirectly?" Pay you must, in any event.

When payment is made directly and in proportion to use, men are apt to avoid waste. This is particularly true of water, electricity and gas. And, by the way, what is there about water that should cause it to be regarded differently from any other necessity that must be bought? Is it more necessary than food? As well might Britannica argue that food should be made free to the residents of a city as that water should be free. As well argue that the butcher should not weigh the meat and let the customer—and his dog—help himself ad libitum, as to argue that water should not be metered. Yet, deceived by the sophism of "Water Almost Free as Air," many a city (Chicago among the number) goes gingerly about the task of metering all its services. Why not make the sophism perfect by enlarging the slogan to read, "Food as Free as Air"?

There is a certain class of politicians who believe that it is popular to oppose universal water metering, yet where is the city that has ever adopted universal metering and afterward reverted to flat rates? The fact is that citizens are not such fools as some politicians imagine. Give them the facts about metering and their opposition soon wanes, if indeed such opposition has ever really existed on the part of the majority.

Reverting again to Encyclopedia Britannica's opposition to water metering, it should be remembered that in Great Britain there has developed a strong tendency to coddle the citizens, as contrasted with our American plan of encouraging each one to shift for himself. The British "dole" for the man out of a job is perhaps the latest evolution of that coddling policy. And what is the "dole" at bottom but an unmetered meal ticket? Just as "free water" encourages waste of water, so the "dole" encourages waste of time. To a pretty pass has this coddling policy brought that great empire. Seeing Americans marching steadily forward toward greater incomes, they attribute our progress mainly to natural resources. Well, if natural resources be the answer, they consist mainly in that part called resourcefulness—desire and ability to paddle one's own canoe.

Equivalent to a Semi-Monthly Municipal Magazine

Two of the *Gillette Construction Group* of magazines are so edited as to embrace the construction and maintenance features of municipal work, namely *Roads and Streets* and *Water Works and Sewerage*. For city engineers, superintendents, contractors and others engaged in municipal construction work, these two magazines are essentially one semi-monthly magazine, the one covering street work, street cleaning and traffic control, the other covering waterworks, sewers, and sewage treatment and disposal. The third magazine of the *Gillette Construction Group*, namely *Engineering and Contracting*, rounds out the picture for those who desire a complete view of progress in the civil engineering and contracting field.

City streets and country roads have been growing more and more alike ever since the advent of the automobile. It was perception of this fact that led us in 1916 to establish *Roads and Streets* (an offshoot from *Engineering and Contracting)* as a magazine useful alike to the city, county and state engineer engaged in highway design, construction and maintenance. As for the contractor in the highway field, the equipment

needed is the same inside as outside a city; and the methods of construction are usually identical. Indeed, were it not that those artificial boundaries known as "city limits," are often marked by signs, a motorist would usually not know when he had passed from the city street to the country road.

Roads and Streets is edited to serve those performing similar functions in the highway field, regardless of their titles. Snow cleaning, which was at one time confined to city streets, is a function that has spread to country roads. And the same is happening as to highway signalling and traffic control. Contrariwise, the cheaper forms of road surfacing (gravelling, etc.) that were formerly regarded as fit only for country roads, are being more and more used on residence streets until such time as the residents feel inclined to pay for permanent pavements. Indeed, there is no sound reason why any city or town street should ever be muddy, although many of them are no better than hog wallows in wet weather. In such cases the residents seem to think that until a permanent pavement can be afforded, they must go without any sort of surfacing. And so they wallow around for a decade, or a generation, waiting till they can afford a roadway, when they might, and should, have one somewhat short of perfection but at least smooth and solid. City engineers can often persuade residents in such cases to adopt some temporary type of surfacing that will eliminate all mud and dust; for, as to highways at least, a half loaf is far better than none.

The annual Road Show has become the mecca of city engineers as well as of county and state engineers, thus proving the community of interest of all who are engaged in highway work.

Water Works and Sewerage might be more briefly called Municipal Hydraulics, and that title was given consideration, but it seemed best to parallel the title of *Roads and Streets* by using two names that designate closely allied branches of the construction field. All consulting engineers, and nearly all city engineers, who specialize in water supply also specialize in sewage disposal. The same holds true of nearly all city contractors who engage in "ditch digging." So the wedding of these two names in the title of our magazine is merely the repetition of a wedding that has existed for generations between these two functions.

In America almost as much money is annually spent for new sewer as for new waterworks systems and betterments. And when the public has been fully convinced to the wisdom of not contaminating rivers, lakes and ocean beaches with sewage, the annual expenditures for sewerage systems will probably exceed those for waterworks.

A word in closing about *Engineering and Contracting*. We have recently added a section entitled "Nuggets of Knowledge on Methods and Costs," in which at least 50 short, nuggety articles are printed every month. This magazine aims to cover the engineering and contracting features of bridge and building construction, and of the miscellaneous structures of a civil engineering nature not covered by *Roads and Streets* or by *Water Works and Sewerage*.

The reader is referred to our advertising section for the subscription rates of these magazines when taken in combination.

The Twin Branches of Municipal Hydraulics

Without an exception consulting engineers who specialize in city waterworks specialize also in sewerage. These two departments of civil engineering are, and always have been, twin branches of one great tree —municipal hydraulics.

Water supply involves water disposal. A sewer is itself a water conduit differing hydraulically from a water supply pipe in that it does not carry water under pressure. But a sewer has the additional function of transporting refuse matter. It is perhaps the most economic conveyor of solids that man has designed, with the possible exception of the hydraulic monitor and sluice used in placer mining.

The primitive form of sewer, still to be seen in many European towns, is the gutter. Barely half a century has elapsed since our American towns began to equip themselves with sewer systems, but they have far outstripped the average European town in this respect. Our next great step will be to provide sewage treatment plants for practically all our towns, for we must not continue polluting our rivers.

The editor was much interested in seeing the ancient waterworks in Pompeii, which was destroyed by a Vesuvius eruption in 79 A. D. No sewer pipes were seen. The water pipes, which are small, are made of lead, and they look quite modern. Underground masonry aqueducts were the "supply mains." The public baths, with their devices for heating the water, are among the most interesting features of this ancient waterworks.

The early Romans solved many problems in hydraulics. Their aqueducts are remarkable engineering structures. Not less so are the massive arched sewers by which every street in Rome was drained into the Tiber. One of these sewers, 11x12 ft., is still in use.

More than 20 centuries ago men had devised and built remarkable water supply and water drainage systems in Rome; and even hundreds of years prior to that long aqueducts and reservoirs of large size had been built to supply many Mediterranean cities. The greatest handicap that the engineers of those early days had to contend with was the lack of iron or steel pipes for distribution of water and terra cotta pipes for removal of sewage. Lead was not only expensive but lacked strength. Bronze was even more expensive. They were driven to the extensive use of canals, long tunnels and masonry aqueducts. Magnificent as some of these structures were, the cost of their construction was enormous.

H. P. Gillette

48th Annual Convention of New England Water Works Association

The 48th annual convention of the New England Water Works Association, held Sept. 17 to 20 at Portland, Me., while not the largest from an attendance standpoint, was one of the most interesting and successful meetings of the association. The total registration was 570, made up of 228 members, 111 associate members and 231 guests.

The opening session on Sept. 17 was devoted principally to the reading of reports of committees. The officers of the association also submitted their reports. The secretary reported a total membership of 830, of which 701 are active members. The treasurer reported that the invested fund totaled some $15,000. The Dexter Brockett medal, which is given each year to the author of the best paper presented before the association, was presented to Francis W. Dean, engineer and architect, Boston, Mass., for his paper, "Pumping Station Practice." This paper was published in the June, 1928, Journal of New England Water Works Association. An interesting feature of the session was the election of Sir Alexander Houston, the famous engineer of the Metropolitan Water District of London, England, to honorary membership in the association.

The afternoon and evening sessions were devoted to the presentation of technical papers. One paper that aroused particular interest dealt with color reduction in storage reservoirs. This was presented by Caleb Mills Saville, Manager and Chief Engineer of the Board of Water Commissioners of Hartford, Conn. Another paper of much interest was "Beauty in Water Works Structure," presented by John C. Stevens, the architect who designed some of the buildings for the Portland Water District. The other two papers dealt with the Portland Water District.

At the morning session on Wednesday two papers were presented. In one of these Percy Sanders, Superintendent of Water Works, Concord, N. H., described that city's experience with automatic chlorination. An abstract of this paper will be found elsewhere in this issue. The other paper, presented by Ralph S. Bauer, Mayor of Lynn, Mass., dealt with the financial administration of a water works. The afternoon was given up to a clam bake and sail on Casco Bay. The water works superintendents' meeting comprised the evening session. At this session the reports of the legislative committee and the committee on painting standpipes were presented. Three papers also were presented: "Test of Large Meters in the Field," by R. E. Ferguson, Assistant Superintendent Hersey Mfg. Co.; "Experiences with Diesel Engines in Water Works Plants," by A. D. Couch, Mechanical Engineer, Community Water Service, and "Diesel Pumping Units at Wayland and Wilmington, Mass. Mr. Ferguson's paper is abstracted in this issue.

At the Thursday session the following papers were presented:

"Method of Testing Cast Iron Pipe," by Wm. R. Conrad (abstracted elsewhere in this issue); "Some Uses of Aeration in Water Purification," by Malcolm Pirnie; a description of the water works improvements at Springfield, Mass., by E. E. Lochridge; "The Reconstruction of the Pumping Station of the Western New York Water Co.," by H. W. Huy; "Making of Water Works and Pressure Studies," by Herbert E. Smith.

At the morning session on Friday, Arthur E. Gorman presented a paper, "Watching the Weather in Safeguarding Public Water Supplies," and J. Frederick Jackson presented a paper entitled, "Enforcement with Other Beverages," which dealt with the control of bathing in public water supplies.

The entertainment features were as follows: Sept. 17, 1 P. M.—Maine clam chowder luncheon at new shops of Portland Water District, followed by inspection of shops and standpipe painting inspection. (Courtesy of Portland Water District.) 8 P. M.—Informal reception for ladies at Hotel Eastland. 8:15 P. M.—Theatre party for ladies. (Courtesy of Geo. F. West & Son.)

Sept. 18, 11:30 A. M.—Clam bake and sail, Casco Bay. (Courtesy of Water Works Manufacturers' Association, Inc.) 8 P. M.—Ladies' reception and bridge at Hotel Eastland. (Courtesy of Water Works Manufacturers' Association, Inc.) Sept. 19, 10 A. M.—Sightseeing trip for the ladies. (Courtesy of Portland Chamber of Commerce.) Followed by coffee at Portland Chamber of Commerce. 7:30 P. M.—Dinner dance and entertainment at Hotel Eastland. (Courtesy of Water Works Manufacturers' Association, Inc.) Golf tournament.

The officers elected for the ensuing year were as follows: Robert Spurr Weston, consulting engineer, Boston, president; George H. Finneran, superintendent water service, Boston, first vice-president; George C. Brehm, city engineer and director of public works, Waltham, Mass., second vice-president. The following continue in office: Frank J. Gifford, Dedham, Mass., secretary; Albert L. Sawyer, Haverhill, Mass., treasurer; Prof. Gordon M. Fair, Cambridge, Mass., editor.

Flume for Testing Models of Hydraulic Structure

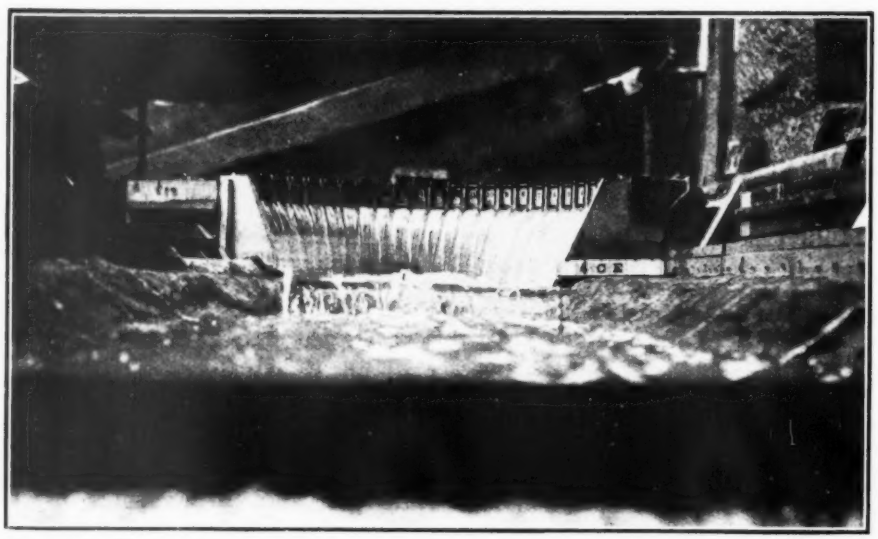
A flume for testing models of dams and other hydraulic structures has been recently installed in the new laboratories of the Carnegie Institute of Technology and experiments on a model of a commercial dam have already been made.

This flume is 72 ft. long, 13 ft. wide, and 3½ ft. deep, and is equipped with a centrifugal pump with a capacity of 3,000 gal. per minute. According to Professor Harold A. Thomas, associate professor in charge of the hydraulic department at Tech, it is probably one of the most suitable flumes in the country for testing hydraulic structures.

The flume is located in the new addition between the north wings of Engineering Hall. To the north of it is the materials testing laboratory, with its new equipment. The materials laboratory was moved from Machinery Hall to provide space for the new aeronautics laboratory.

Both undergraduate and research study will be made on models in this flume. Spillways, outlets, cushion pools and other hydraulic equipment will be tested. Model dams can be constructed and easily fitted into place and the stream of water controlled to reproduce the flow of a river on which the dam will be built according to the laws of similitude.

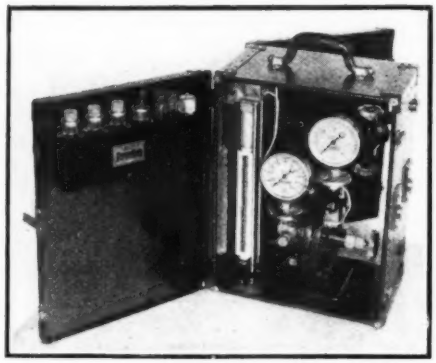
During the summer months commercial engineers have been cooperating with Professor Thomas on the model of a dam now being built in the south. The model, built on a scale ratio of 1 to 100, was constructed by Mr. William Pfouts, head instructor of patternmaking at Carnegie Tech. Every detail of the prototype was reproduced in the model. Even the topography of the river bottom was carefully reproduced with concrete. Professor Thomas states that other models will be tested in the near future.



Test Being Made on Model Dam at Hydraulic Laboratory, Carnegie Institute of Technology

A New Portable Chlorinator

The Paradon Mfg. Co. of Arlington, N. J., have recently developed an unique new portable chlorinator. The apparatus is housed in a tough fibre case, constructed similar to a piece of hand luggage. When closed, it looks exactly like a piece of baggage, and will readily pass as such, making its transportation easy.



New Paradon Portable Chlorinator.

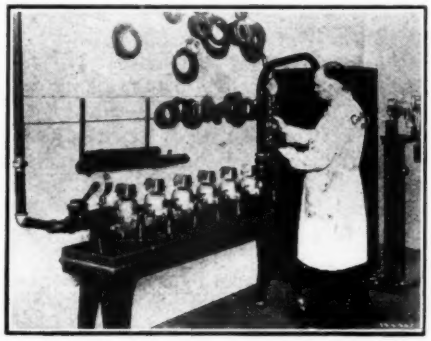
A complete standard dry feed Paradon chlorinator is used, fully equipped to the last detail. The unit is adaptable to continuous regular chlorinating service as well as occasional emergency use. A silver chlorine shut-off valve is provided, making it possible to keep the apparatus under chlorine pressure when not in use, thus preventing access of moisture and other foreign material, and allowing long periods of disuse with attendant deterioration of the unit.

No water supply is necessary for its operation. The apparatus can be supplied for any range of capacity from 1 lb. of chlorine per 24 hours to 300 lb. per 24 hours. Equipment can also be supplied that will decrease the minimum capacity to .03 lb. of chlorine per 24 hours. A chlorine testing outfit, spare parts, connection to main, and all other necessary accessories are contained in the carrying case of the apparatus. A similar fibre carrier is provided for two small cylinders of chlorine (12 lb. capacity each), and which can also be used in conjunction with the portable chlorinator.

The uses of the Paradon portable chlorinator are many, as, for sterilizing mains before putting into use, for eliminating after pollution in dead ends of mains, etc., for algae control, as a steady unit for regular chlorination, for the chlorination of emergency supplies due to broken mains, low water, etc., for the chlorination of water supplies used in connection with construction work on water sheds, for prechlorination, double chlorination, etc., also in sewage work for fly control, biological oxygen demand control, odor control; in fact, the portable chlorinator may be used to control the application of chlorine for any use that chlorine can be put to.

Testing Six Meters at One Time

The city of Bloomington, Ill., keeps close check on the revenue of its water department by regular testing of water meters. The illustration shows the testing of six meters at one time with the Clark No. 622 meter tester, "weighing type." This multiple tester is stated to have effected very great savings in the testing costs of the department as well as insured accuracy of the meters —which has resulted in almost entirely eliminating complaints from consumers regarding charges.



Meter Testing at Bloomington, Ill.

Sewer Systems in Iowa.—Of the 920 cities and incorporated towns in Iowa, 319 have sewer systems. These systems serve 1,183,000 people, or 84.5 per cent of the total urban population. Of the 93 second class cities with populations ranging from 2,000 to 15,000 only one has no sewer system. Of the 96 incorporated towns with populations between 1,000 and 2,000, 85 have sewer systems. Of the smaller towns ranging from 500 to 1,000 in population nearly 50 per cent have sewer systems.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Gardner-Denver Increases Plant at Quincy

It is reported that contracts were let this week for the new building addition of the Gardner-Denver Co. plant at Quincy, Ill. This will give a 50 per cent increase in production and it is expected it will be finished in 90 days.

Unfilled orders of the company have not diminished, it was announced today by Ralph G. Gardner, vice-president. With additional manufacturing space this fall, production will soon be much nearer the sales demand, he said.

The Gardner-Denver Co. also has plants at Denver, Colo., and Quincy, Ill. It manufactures slush pumps, air compressors, pneumatic tools, drill sharpeners and high pressure drill steel forges.

Herbert Kennedy Company to Represent Michigan Valve in Eastern Territory

The Michigan Valve & Foundry Company have recently appointed the Herbert Kennedy Company of 22 E. 42nd St., New York City, their representatives in New York, Massachusetts, Vermont, Connecticut, New Hampshire, Rhode Island and Maine to cooperate with municipal executives and engineers in the supply of valves, hydrants, sluice gates and other appurtenances for water works, filtration and sewerage systems.

The Herbert Kennedy Company are also the selling agents in the United States for the Pont-A-Mousson Cast Iron Foundries at Nancy, France, the largest complete unit in the world devoted exclusively to the production of cast iron pipe and fittings.

The extensive properties of the French company at Pont-A-Mousson during the war were practically in the front lines of the French army and received a good deal of attention from the German artillery just prior to the advance of the American first army in the fall of 1918. During the progress of these military operations the foundry was completely destroyed and not again re-habilitated until after 1921. Since then, however, it has been completely rebuilt and thoroughly equipped with the most modern equipment. It is now producing in excess of 500,000 tons per year.

The Herbert Kennedy Company will also represent, as exclusive selling agents, the Inter-Continental Pipe & Mining Company, now constructing a large pipe foundry at Chelsea, Mass.

In anticipation of the distribution of products from the new unit, the Herbert Kennedy Company will expand their sales organization, which for the past five years covered only the seaboard states. As soon as the Chelsea plant gets under production, this sales organization will have been made national in scope.

The Herbert Kennedy Company has always specialized in products sold to municipalities and public utilities and are consequently prepared to cooperate to the fullest extent with the officials responsible for the purchasing and operation of water works and sewerage equipment.

Changes in Link-Belt Personnel

From the executive offices of the Link-Belt Company comes the announcement of the resignation of Mr. F. B. Caldwell, vice-president of the Chicago plant, on account of health.

Mr. W. C. Carter, formerly vice-president in general charge of production at all Link-Belt plants, will assume the duties of vice-president and general manager of the Chicago plant.

Mr. E. J. Burnell, who was manager of the Pittsburgh office, has been appointed sales manager of the Western Division, with headquarters at the Chicago plant.

Mr. Nels Davis, from the Chicago engineering sales force, succeeds Mr. Burnell.

W. C. Carter, Recently Made General Manager for Chicago Plant of Link-Belt

Ray P. McGrath

On September 3rd, Mr. Ray McGrath, who for fifteen years has been manager of the San Francisco office of the Sullivan Machinery Company, passed away.

Mr. McGrath has been associated with the Sullivan Company since 1906. He was connected with the New England sales office of the company at Boston until 1914, when he was appointed manager at San Francisco. He was one of the most widely liked and most highly respected members of its sales organization, and his death is a great loss to his company and host of friends.

New Representative In East for Trimont

W. K. Hughes, who for the past ten years has represented Peck, Stow & Wilcox Company in the Pennsylvania and Atlantic seaboard territory, has become associated with the Trimont Manufacturing Company of Roxbury, Mass. This company is well known as makers of Trimo tools.

Mr. Hughes will represent the Trimont Company as a direct representative in charge of eastern sales.

Change of Address

The Houston office of the Chain Belt Company, Milwaukee, manufacturers of Rex deep well oil chains, conveyors and concrete mixers, has moved to larger quarters at 1310 Second National Bank Building. They were formerly located at 1000 Marine Bank Building. Mr. Russell G. Davis is manager.

Paradon Appoints New Representative for Southwest Territory

The Paradon Manufacturing Company of Arlington, N. J., announces the appointment of Mr. Roy E. King as assistant to Mr. L. K. Cecil, 214 Atco Building, Tulsa, Okla., sales representative for the Paradon chlorinators in the states of Arkansas and Oklahoma.

Mr. King has just recently returned to Tulsa from the factory at Arlington, where he underwent a thorough training in the servicing of Paradon chlorinators.

The U. S. Piper, the attractive quarterly paper of the United States Pipe & Foundry Company, Burlington, N. J., presents a story of the installation of a 60-in. cast iron pipe line to insure abundant water supply for Atlantic City.

Japanese Quick to Adopt Modern Methods

The New Nomura Bank in Tokyo is an example of the enthusiasm and readiness with which the Japanese adopt modern ideas. A correspondent for the Chicago Pump Company, manufacturers of the well known "Flush-Kleen" Ejector, writes:

"The Japanese, after being convinced of the merit of an idea, are quick to adapt and use that idea.

"In evidence of the Japanese progressive attitude, we cite their use of the same materials and methods in their new buildings as we use over here. Japan, because of its enthusiasm and readiness to use modern ideas, makes that country a splendid field for American products."

One type of American product used in the new bank is the "Flush-Kleen" Ejector, which uses the flow reversal principle of ejector.

Link-Belt Appoints Distributors

Link-Belt Company of Chicago have just completed negotiations with several organizations throughout the country to act as sales agents for their complete line of cranes, shovels and draglines.

Mr. Charles L. Miller, of Denver and Salt Lake City, will handle Utah, Colorado and the Intermountain territory.

In Alabama, Mr. James Van Buskirk, 911 Martin Bldg., Birmingham, will purvey this equipment.

The Clyde Company, located at 309 Magazine St., New Orleans, are now taking care of the business throughout the state of Louisiana and the south half of Mississippi, with the exception of a few counties in the very southeast corner.

In a radius around Memphis, Tenn., the Holloran Tractor Company at 188 Butler Ave., that city, will now tell you about this complete line of machines.

The territory of Greater New York, including Westchester, Nassau and Suffolk Counties, can learn from the United Hoisting Company, 136th and Locust Sts., New York, facts and interesting data about Link-Belt machines.

Ensminger & Company, 181 S. Washington St., Wilkes-Barre, Pa., are well posted on the entire line of Link-Belt cranes, shovels and draglines, and will be pleased to tell you about them.

Copies of the Crane Book, recently issued by Link-Belt, may be obtained through any of these agents. This book shows many novel and practical uses for their line of equipment. These agents will also be glad to have the publication "Shovel News" sent readers gratis. It is devoted to the use of these machines and is issued every other month.

Cleveland Tractor Company at the National Air Races

Model "100" Cletrac, handsomely decorated, and representing POWER, constituted the entry of the Cleveland Tractor Company in the parade of floats and marching units depicting Cleveland's industries and organizations in the pageant on the opening day of the National Air Races and Exposition held in Cleveland recently.

The parade started five miles out and moved down historic Euclid Ave., with the Public Hall the final destination and disbanding point. The races and field events took place at the Cleveland Airport, and the exposition of airplanes together with all kinds of aeronautical equipment was staged in Cleveland's mammoth Public Hall.

Sullivan Office at Huntington Changes Local Address

The Sullivan Machinery Company's branch office and warehouse at Huntington, West Virginia, were moved September 1, from their old address at 736 Third Avenue to new quarters at 702-704 Eighth Avenue.

The new location gives additional space and convenience for the office, and better warehouse facilities, as it is on a side track and near the C. & O. Railroad station. A considerable stock of Sullivan Coal Mining equipment and spare parts is maintained at Huntington; also of air compressors and drills.

The Contract Drilling Department of the company also maintains a depot at this point for Diamond Drilling equipment, and supplies necessary service for prospecting jobs in Virginia, West Virginia, Eastern Kentucky and Tennessee.

Mr. J. S. Walker, Jr., is manager of the Huntington office.

W. S. Leech Joins Basford Company

Willoughby S. Leech, well known in Pittsburgh, through his former sales and advertising connections with some of the large manufacturing companies in that district, including Westinghouse Electric & Manufacturing Company and A. M. Myers Company, has joined the staff of G. M. Basford Company.

To care for the expanding business among the industrials of western Pennsylvania and Ohio the Basford Company has opened a branch office in the recently completed Koppers Building, Pittsburgh, where Mr. Leech will be permanently located. The counsel of Mr. Leech on advertising matters is available to all clients of the G. M. Basford Company.

Thank You

We are glad that Mineralead is supplied in solid form, for it has come to us as a very attractive and useful paperweight, the editor's best friend in a windy city. It is now at work holding our papers together, and we thank the manufacturer, The Atlas Mineral Products Company of Mertztown, Pa.

However, paperweighting is not the real purpose of Mineralead for it was developed by its sponsors as a jointing material for Bell and Spigot cast iron pipe. They will be glad to tell you all about it, and if you can use a paper weight maybe the manufacturer will send you one, too.

The Paradon Manufacturing Company, Arlington, N. J., announces the appointment of Mr. William H. Fulton as chief engineer of the company. Mr. Fulton will have full charge of the design and development of Paradon Chlorinating apparatus and other projects of the company.

Contract Welding

A man experienced in Oxy-Acetylene welding would like yearly contract with supply company for making welded product on small scale. Name furnished upon request.